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ACUTE INTESTINAL OBSTRUCTION

EVALUATION OF RESULTS IN TWENTY-ONE HUNDRED FIFTY CASES; WITH DETAILED STUDIES OF TWENTY-FIVE SHOWING POTASSIUM AS A TOXIC FACTOR

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IN THE Orient, the problem of the neglected case of acute intestinal obstruction is difficult and the mortality high. Even in the United States, despite advances in surgery and a clearer knowledge of many of the altered biochemical reactions, the death rate during the last 15 years has varied little (10.1 to 11.1 per 100,000), but the total number is constantly increasing.[84a]

Mortality rates from as high as 61 per cent[84] to as low as 19 per cent[52] indicate what little uniformity exists regarding treatment and operative procedure. In comparing the results obtained for similar lesions at different hospitals, this disparity becomes especially apparent. For these reasons, Lincoln Davis[98] objected to the evaluation of statistics from various institutions unless they could be compared case by case.

Since the observations of Leichtenstern[64] and Nothnagel,[89] the pulse rate has been used as a criterion in prognosis. In Miller's[84] series, 71 per cent of the fatal cases exhibited either a subnormal temperature, or one above 100° F. A rapid, shallow respiration was stressed by Braun and Boruttau[9] as an ominous sign in obstruction.

In the neglected case, the quick pulse, the rapid respiration and the elevated or subnormal temperature contrast strongly with the normal values found in the early one. In order to test whether a combination of these three variables would give a truer picture of the patient's condition, and thus afford a measure whereby the relative toxic state of each might be gauged, an index combining them was derived and applied in 570 cases of acute intestinal obstruction.[106]

Determination of the Index.—The index is the product of the three variables: Temperature, pulse, and respiration. The normals taken are: Temperature, 98.6° F.; pulse, 72; respiration, 16. To each, an arbitrary value of one is given.

Temperature Factor: For each rise or fall of one degree Fahrenheit, one is added to the normal of one.

Pulse Factor: For every rise of ten in the pulse rate, one is added to the normal of one.

Respiratory Factor: For each rise of five in the respiratory rate, one is added to the normal of one.

Example: A strangulated hernia of three days' duration was admitted with: Temperature, 99.6° F.; pulse, 112; respiration, 26. Index in this case: 2 x 5 x 3 = 30 as compared with Normal Index 1 x 1 x 1 = 1.

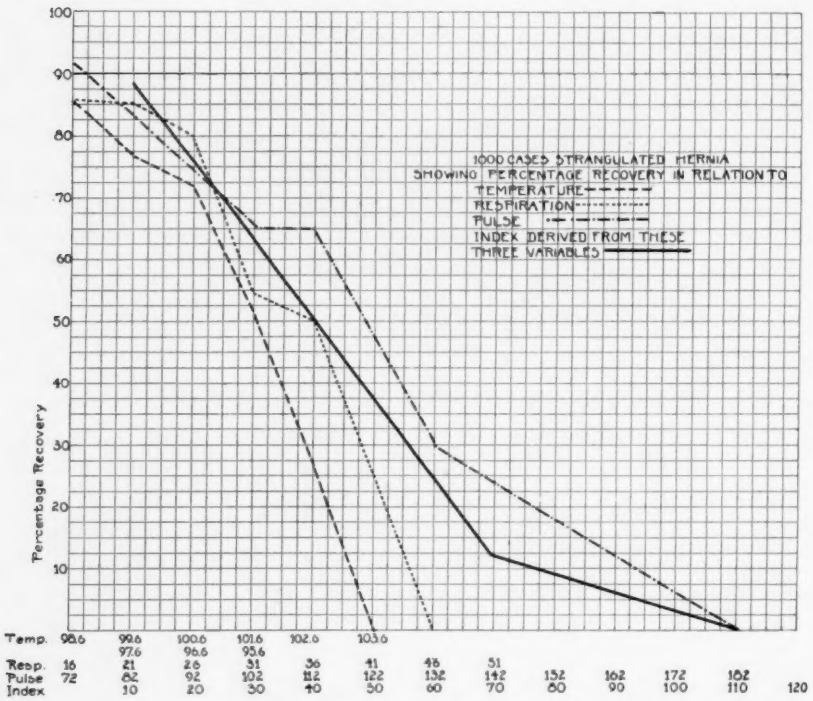


CHART 1.—Ordinates: Temperature, pulse rate and respiration; index. Abscissas: Percentage of recovery.

TABLE I

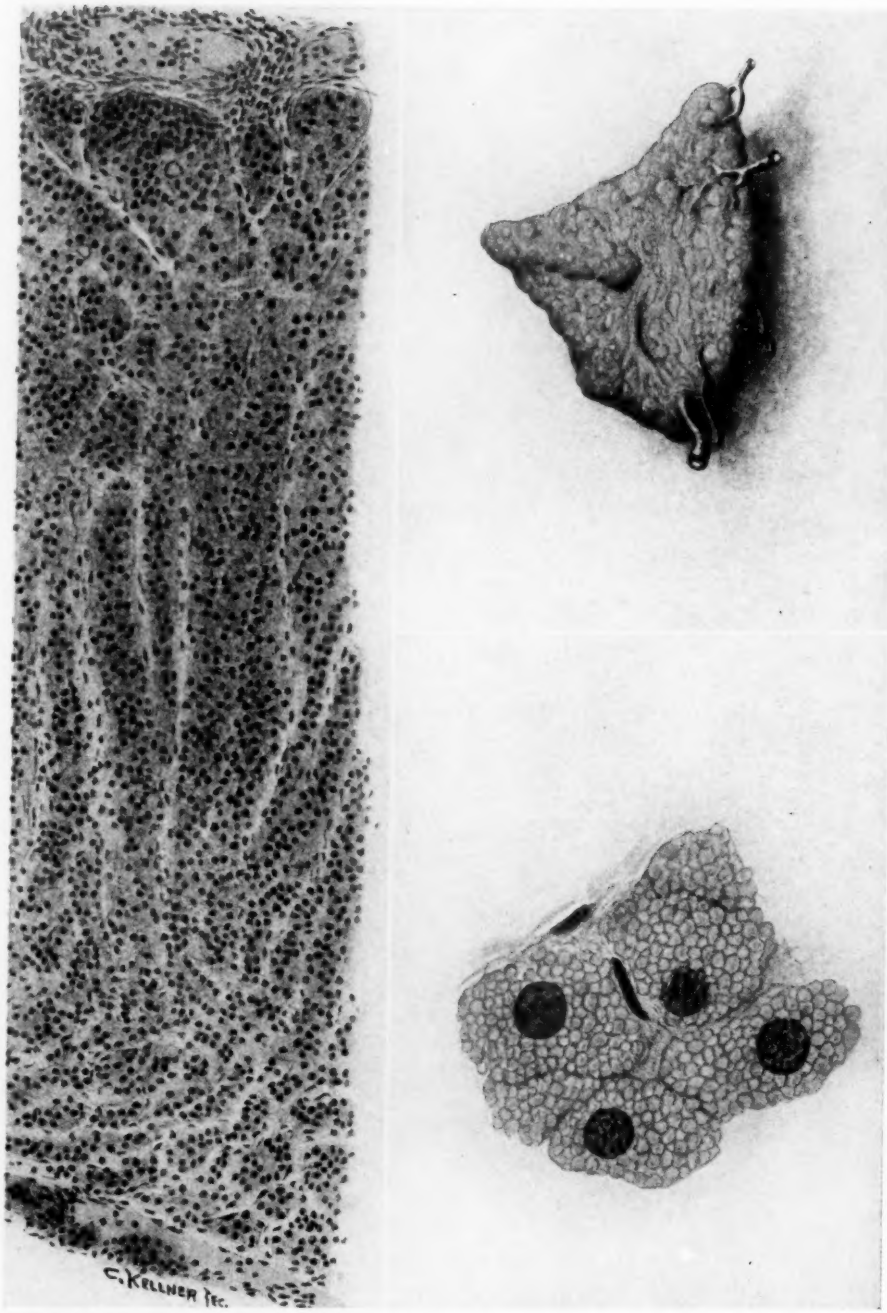
DETERMINATION OF FACTORS

Temperature Factor	Pulse Factor	Respiration Factor
98.6° = 1	72 = 1	16 = 1
97.6°, 99.6° = 2	82 = 2	21 = 2
96.6°, 100.6° = 3	92 = 3	26 = 3
95.6°, 101.6° = 4	102 = 4	31 = 4
102.6° = 5	112 = 5	36 = 5
103.6° = 6	122 = 6	41 = 6

The indices of 1,150 cases of acute mechanical obstruction (Group I*) were determined and charted, with the recovery rate plotted against the index. The declivity of the line shows that survival stands in inverse proportion, and mortality in direct proportion to the magnitude of the index.

PLATE I

NORMAL HUMAN ADRENAL CORTEX



A right adrenal gland of approximately normal size, shape and color showing the superior, middle and inferior arteries, the central vein and an alternate venous drainage (upper right). Camera lucida painting of a segment of a frozen section of adrenal cortex from the capsule (with capsular artery in cross-section) to the juxtamedullary border. The lipoids are stained orange-red with Sudan III, and the nuclei blue with Harris' hematoxylin. The section was mounted in Zwemer's glychrogel. ×120 (left). A few lipoid-rich gland cells from the outer fascicular zone of the above section. A diminution of this type of cell is associated with a demand on the gland. The nuclei of two capillary endothelial cells are also illustrated. ×900. (lower right.)

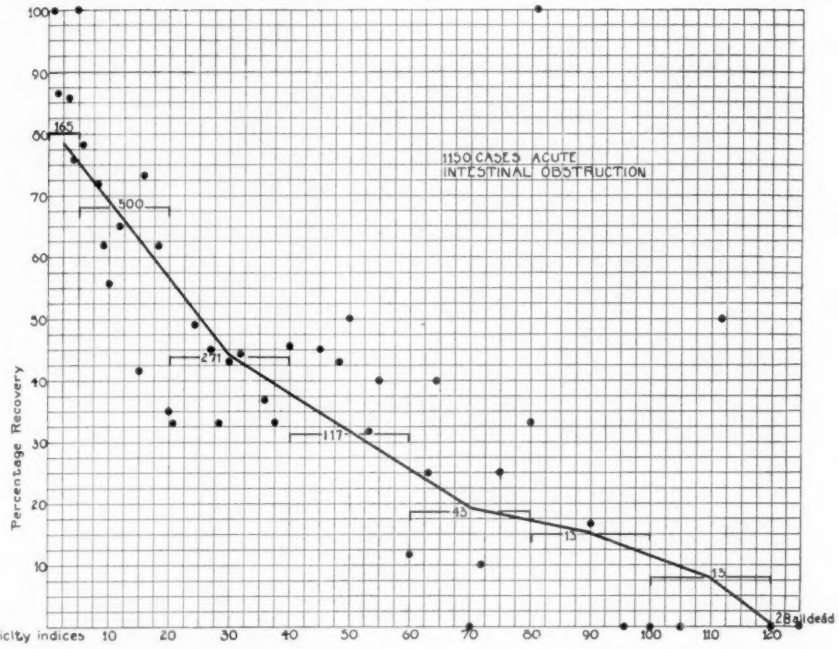


CHART 2.—Ordinates: Toxicity index. Abscissas: Percentage of recovery. Scatter diagram showing the percentage of recovery for each index. Brackets indicate the number of cases and the range of indices taken for each point on the chart.

This same correlation is seen in 1,000 cases of strangulated external hernia (Group III*) (Chart 3).

Analysis of the Results of Operative Procedures.—With the objective value of the index revealed in 2,150 cases† the types of surgical procedures were gauged in respect to the patient's condition.

The reduction of a strangulated hernia with viable intestine gave the optimum prognosis in all cases. The addition of an enterostomy raised the mortality. In the gangrenous hernia, a resection with primary anastomosis augured better than did the principle of marsupialization (Chart 4).

In analyzing the 925 operations with viable intestine, the relief of obstruction, whether effected by division of the adhesions, detorsion of a volvulus, or reduction of an intussusception, offered the patient the best chance as judged by 76 per cent recovery in 520 cases, and a higher survival at each index up to 60 (Chart 5).

A primary enterostomy with the relief of obstruction raised the mortality rate in 149 cases. Grouped as to indices, the recovery rate was lower in those

* Cases of obstruction are grouped according to the Massachusetts General Hospital plan: Group I: Acute mechanical obstruction, except those due to neoplasms. Group II: Obstruction due to neoplasms. Group III: Obstruction due to strangulated external hernia. This paper does not include Group II, nor children under 12 years of age.

† The statistical data were reviewed by Dr. E. B. Wilson of the School of Public Health, Boston. The scatter diagrams were made at his suggestion.

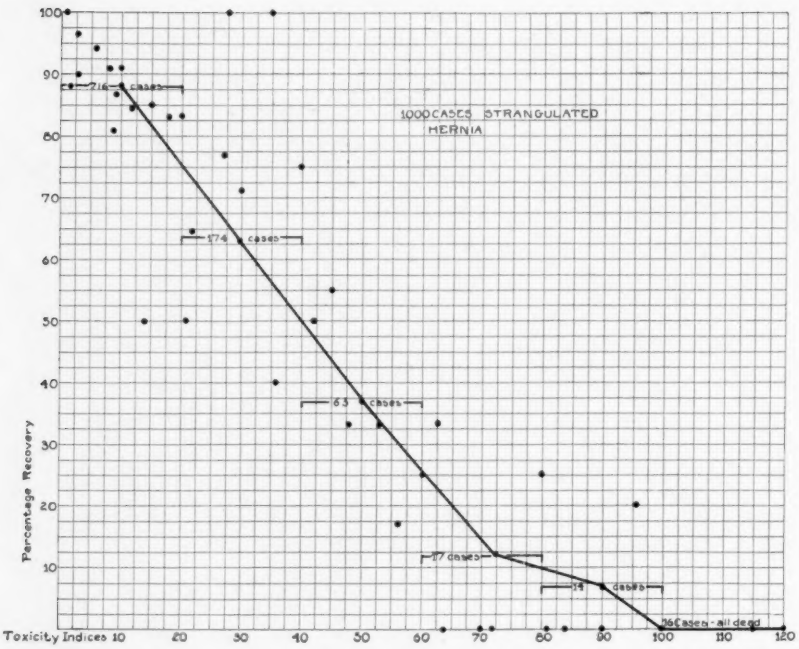


CHART 3.—Ordinates: Toxicity index. Abscissas: Percentage of recovery. Scatter diagram showing percentage of recovery for each index. Brackets indicate the number of cases and the range of indices taken for each point on the chart.

enterostomy cases below 60, and about the same for both the enterostomy and nonenterostomy groups above this index (22 and 19 per cent respectively).

Enterostomy or cecostomy *without* the removal of the lesion gave a 70 per cent mortality, a figure worse than that reported by Treves,[122] in 1884. A short-circuiting operation around the lesion failed to achieve the same success as did its removal.

TABLE II

PERCENTAGE OF RECOVERY IN 2,150 CASES OF ACUTE INTESTINAL OBSTRUCTION, GROUPED ACCORDING TO ETIOLOGY (CHILDREN UNDER 12 EXCLUDED)

GROUP I (Massachusetts General Hospital Classification) Lesion	Lived	Died	Total	Recovery Per Cent
Bands and adhesions	360	213	573	63
Volvulus of small intestine	90	66	156	58
Volvulus of large intestine	70	57	127	55
Intussusception	38	31	69	55
Miscellaneous	18	18	36	50
Gallstones and foreign bodies	8	9	17	47
Meckel's diverticulum	6	9	15	40
Internal strangulated hernia	14	22	36	39
Cause not ascertained	24	62	86	28
Mesenteric thrombosis	4	31	35	11
Totals	632	518	1,150	55
GROUP II Obstruction due to tumors not included.				
GROUP III Strangulated external hernia	765	235	1,000	76.5
Total of Series	1,397	753	2,150	65

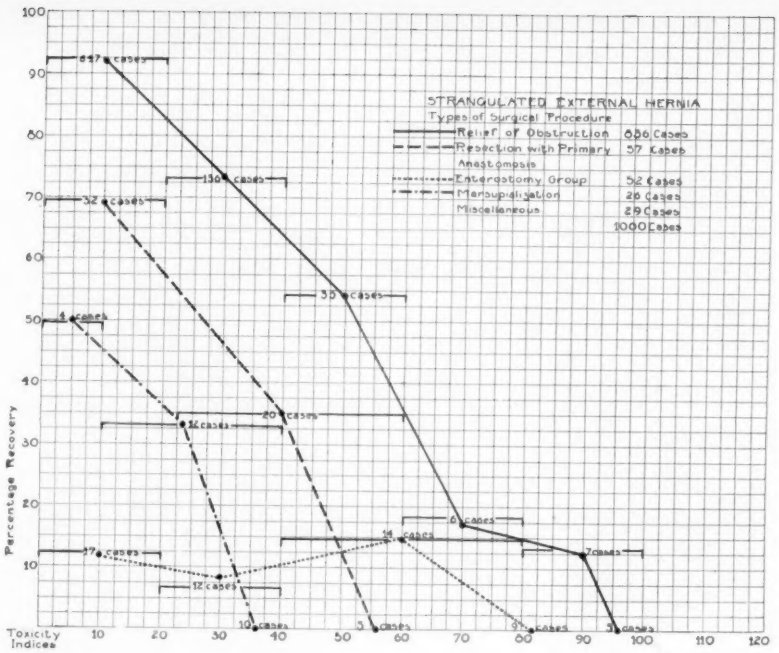


CHART 4.—Ordinates: Toxicity index. Abscissas: Percentage of recovery. Surgical procedures in 1,000 cases of strangulated hernia. Brackets indicate the number of cases and the range of indices for each point on the chart.

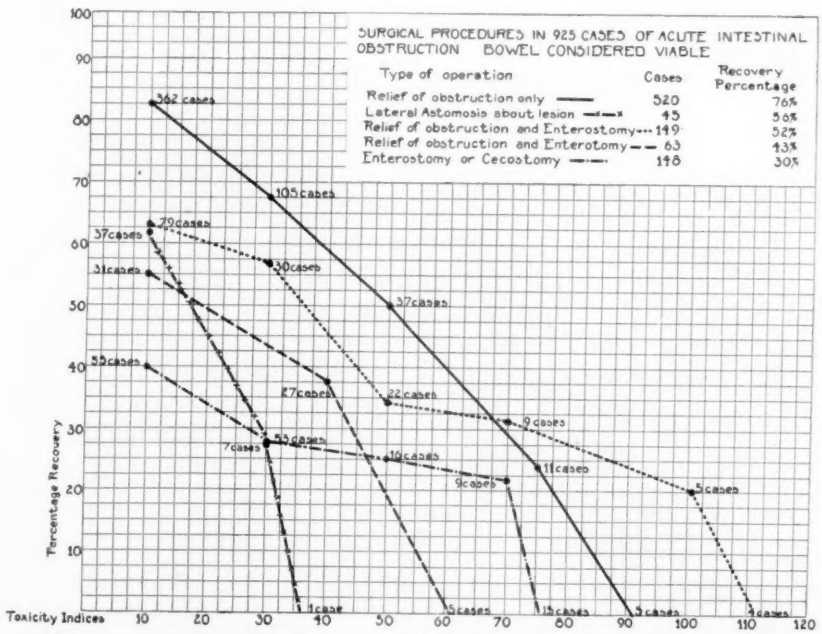

SURGICAL PROCEDURES IN 925 CASES OF ACUTE INTESTINAL OBSTRUCTION BOWEL CONSIDERED VIABLE
Type of operation
Cases
Recovery Percentage
Relief of obstruction only 520 76%
Lateral Astomosis about lesion 45 56%
Relief of obstruction and Enterostomy 149 52%
Relief of obstruction and Enterotomy 63 43%
Enterostomy or Cecostomy 148 30%
Percentage Recovery
Toxicity Indices

CHART 5.—Ordinates: Toxicity index. Abscissas: Percentage of recovery. Contrast of the recovery rate for different surgical procedures in 925 cases of obstruction. The figures represent the number of cases. For example, there were 362 cases, whose indices ranged from one to 20, in which the obstruction was relieved. The percentage of recovery for this group was 82.5. The next figure, 105, indicates that number of cases whose obstruction was relieved. The indices for this group fell between 21 and 40. The percentage of recovery was 67.5. In the same range of indices there were 30 cases which had the obstruction relieved and a primary enterostomy; their percentage of recovery was 10 per cent less than the 105 cases who did not have a primary enterostomy with the relief of obstruction.

In analyzing the 178 cases with gangrene of the intestine, a resection with a primary anastomosis in the mildly toxic case was preferable, whereas, in the severely ill patient, resection with delayed anastomosis gave better results. Again, the exteriorization of the gangrenous bowel carried the greatest number of failures.

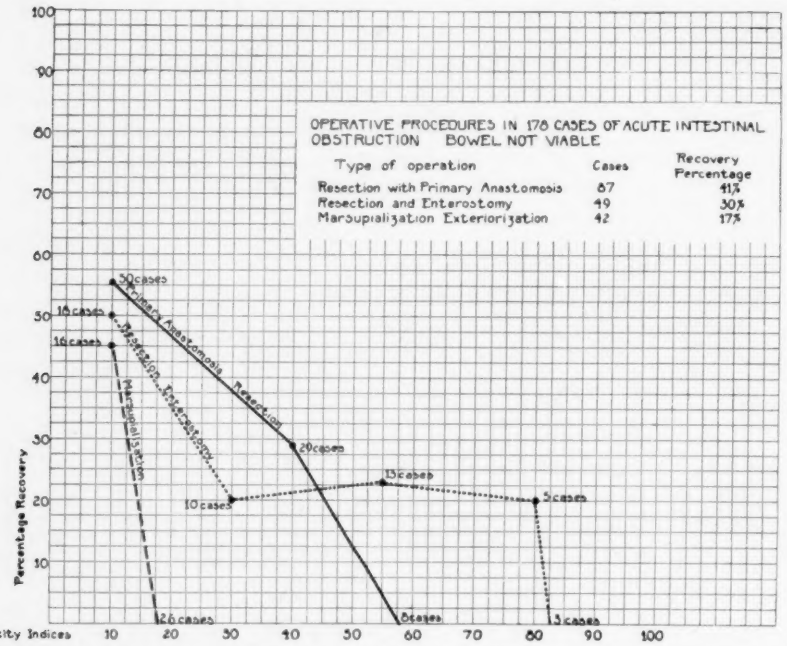


CHART 6.—Ordinates: Toxicity index. Abscissas: Percentage of recovery. Contrast of recovery rate for three different surgical procedures used in dealing with gangrenous intestine. Marsupialization of the loop was not as successful as resection and enterostomy or resection with primary anastomosis.

After summarizing these cases, we are forced to again raise the following questions*: What is the toxic depressor substance in acute intestinal obstruction? Why is strangulation or gangrene more rapidly fatal? In what manner does an enterostomy increase the mortality? Why is gastric lavage beneficial? Why is the slow pulse so often misleading? Finally, how does salt solution mitigate the toxemia of obstruction?

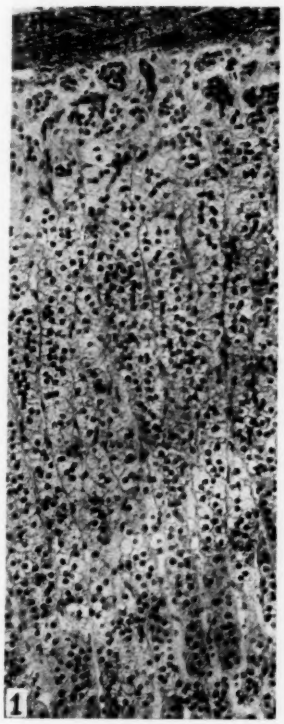
Our attention was directed to the adrenal glands by Wohl, Burns and Clark,[130] who reported cortical cell depletion in experimental obstruction un-

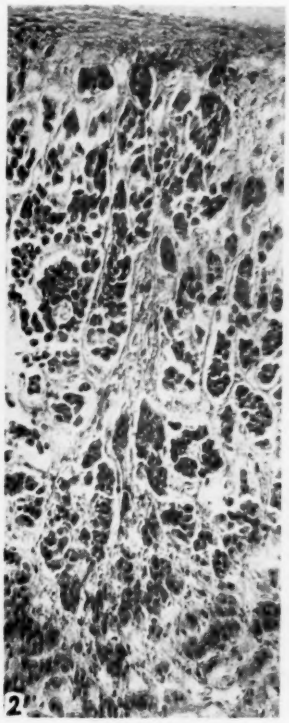
LEGEND FOR PLATE II.—Normal human adrenal cortex. Segment of a median section. Note large clear cells which contained lipoid (×100). Nos. 2 and 3.—Adrenal cortex sections (full width) from two patients dying of intestinal obstruction. Note disorganized cell arrangement and presence of connective tissue between cell columns. It resembles Type 7 or 8 of Zwemer's[133] classification. Postmortem cell changes and shrinkage due perhaps to technic should be discounted (×100). No. 4.—Same adrenal as No. 1 at a lower magnification, to show cell types from capsule to medulla (×60). No. 5.—Normal cat adrenal cortex. The relative thickness of rounded adrenals is greater than that of the folded primate type (×60). No. 6.—Adrenal cortex from Cat No. 3636 showing absence of lipoid-loaded "spongiocytes." This animal died three and one-half days after esophageal obstruction (×60).

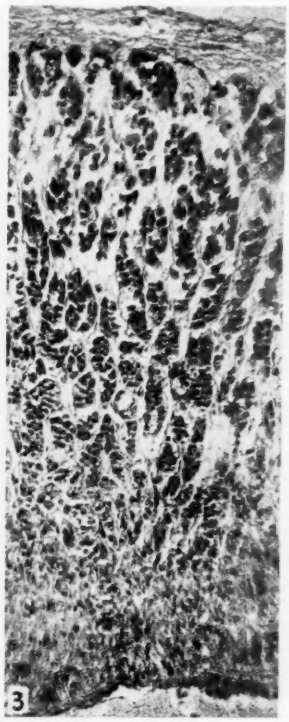
*A more complete discussion and bibliography is given by Cooper, H. S. F.: Cause of Death in High Obstruction. Arch. Surg., 17, 918–967, 1928; and by McIver, M. A.: Acute Intestinal Obstruction. New York, Paul B. Hoeber, Inc., 1934.

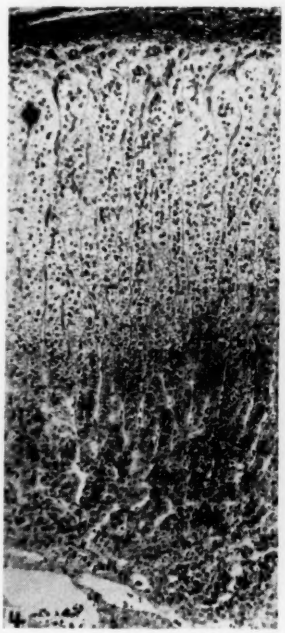
PLATE II

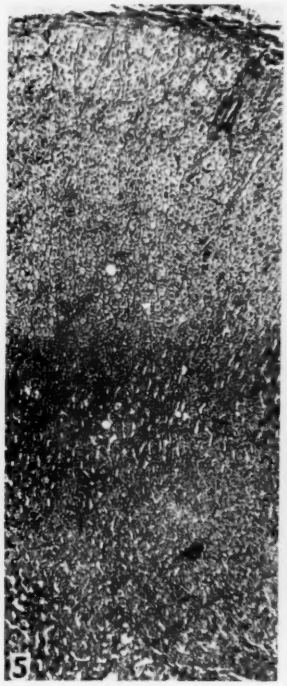
PHOTOMICROGRAPHS ILLUSTRATING VARIOUS PHASES OF ADRENAL HISTOPATHOLOGY

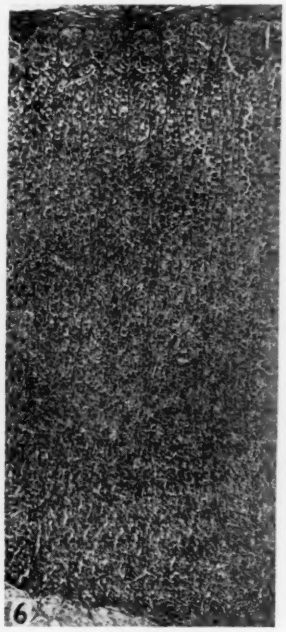












See opposite page for legend.

treated by saline solutions. Examination of sections secured from autopsy cases at the Peter Bent Brigham Hospital revealed various stages of cortico-adrenal depletion according to the classification of Zwemer.[133]

Acute intestinal obstruction and adrenal insufficiency have many features in common. With the latter a definite disturbance in potassium metabolism has been shown to exist.[1, 7, 42, 49, 69, 137] In experimental obstruction in cats, we have reported a rise in blood potassium to lethal levels. The potassium values for the contents of obstructed loops, peritoneal fluid and vomitus were many times that of blood.[107] In experimental intestinal obstruction in dogs, Cutler and Pijoan[19] confirmed the occurrence of a hyperpotassemia.

Coincident with the experimental work, studies were begun on patients. We report here 25 cases; in 20, potassium determinations were made on blood secured at the time of admission; in two, the blood was taken after the administration of therapy; and in three, after operation.

Methods.—Unless otherwise stated, fasting blood was collected in the morning by the same person. The sample was drawn with a sterile dry syringe from the antecubital vein without a tourniquet and placed into a Sanford-Magath hematocrit tube containing heparin. After centrifuging at 3,000 r.p.m. for one hour, the cell volume was read, and plasma separated immediately from the cells. Samples showing any hemolysis were discarded. The potassium content of 0.1 Ml. of whole blood and 0.4 Ml. of plasma was determined by the method of Truszkowski and Zwemer.[123, 123a] The values given represent the average of two determinations, differing by not more than ± 2 per cent from the mean.

The specific gravity of whole blood and plasma was measured by the falling drop* method of Barbour and Hamilton.[6] Plasma protein was calculated by the formula of Weech, Reeves and Goettsch.[127]

The following figures are given as normal for potassium in the blood of humans: Whole blood, 164 to 200 mg. per cent; serum potassium, 18 to 21 mg. per cent; cells, 350 to 465 mg. per cent, average, 418 mg. per cent. Because of the wide normal range, emphasis should be placed on the change in potassium level rather than in absolute values.[56, 57, 74, 88]

Summary of the Potassium Content Data.—*Plasma Potassium:* In the 20 untreated patients, whose blood was taken on admission, the plasma potassium was raised in seven (Cases 1, 2, 3, 4, 9, 19, 20) and low in five (Cases 5, 8, 14, 16, 18), the highest value being 33.4 mg. per cent (Case 9) and the lowest 13.4 mg. per cent (Case 5). In Case 23, a plasma potassium value of 28.2 mg. per cent was found after 300 cc. of 5 per cent salt solution. Plasma K. decreased in 12 following administration of saline and other treatment.[120] In two (Cases 14 and 22), despite saline, there was an increase in the plasma value. Both cases showed extention of the gangrenous process at autopsy.

Case Report.—Case 20: Bronchopneumonia complicated by a strangulated femoral hernia.[56] Plasma potassium was high, rising to 30.1 mg. per cent following operation;

* Pipettes may be obtained from Eimer & Amend, New York.

decreasing after the administration of eschatin† and salt solution but again climbing to 32.3 mg. per cent in spite of further therapy. Elimination by kidneys poor as indicated by oliguria and a rise in the N.P.N. The K. in the urine, however, was 450 mg. per cent. Profuse sweating and muscular twitchings were prominent features.[108]

Cell Potassium.—In 20 untreated cases the average cell potassium was 359 with a range of 302 to 438 mg. per cent. In 14 of these, cell K. was distinctly low. Treated by injections of salt solutions, cell potassium rose in 12 (Cases 3–9, 11, 13, 14, 15, 18); and fluctuated in Cases 10, 13, 16, 19 and 20. In other conditions the importance of cell K. changes has been stressed.[51, 88a]

Whole Blood Potassium on admission was above normal in five (Cases 5, 6, 7, 12, 13), and low in Case 20.

Peritoneal Fluid Potassium varied from 13.2 to 28.6 mg. per cent in 11 cases.

Spinal Fluid Potassium was lower than the plasma potassium when they were taken simultaneously in Cases 11 and 12.[27]

Potassium Content of Gangrenous Loop Fluid.—The values ranged from 109 to 637 mg. per cent in four cases (Cases 5, 14, 20, and 22). Death occurred in all.

Potassium Content of Enterostomy Fluid.—Analysis of potassium in both plasma and enterostomy fluid in Case 9 showed the results to be identical.[20, 128] In Case 25, the intestinal fluid K. was twice that of plasma.

Potassium Content of Gastric Fluid.—In eight cases (Cases 14, 16, 18, 19, 20, 22, 24 and 25) determinations of potassium in both plasma and gastric contents showed a range in the latter from 18.5 to 65.8 mg. per cent; the average concentration of the gastric juice potassium being 2.5 times that of blood taken simultaneously.[54, 107]

Plasma Specific Gravity.—The average in 18 cases was 1.0297 with a range from 1.0264 to 1.0379. This contrasts with the average normal plasma density of 1.0260 to 1.0270.

Hematocrit.—This showed 48.2 per cent cells in the 20 untreated cases with a range from 33 to 59 per cent. This average of 48.2 per cent contrasts with the normal figure of 45 per cent.

Plasma Protein.—In the untreated cases the average plasma protein was 7.8 Gm. per cent with a range from 6.6 to 10.6 Gm. per cent. This is higher than the average normal of 7.0 Gm. per cent.

Discussion.—Certain phenomena associated with acute intestinal obstruction may be partly explained by considering potassium in their interpretation.

Simple Obstruction.—In the progressive dehydration accompanying this lesion, a lethal rise in blood potassium has been demonstrated experimentally, the rapidity depending upon the site of obstruction.[107]

Intestinal Strangulation and Gangrene.—Interference with the vascular supply of the intestines is always associated with a higher mortality. In our experimental work, we attribute the earlier development of toxemia to a more rapid and sustained rise in blood potassium, occasioned by a loss of fluids,

† Eschatin has been furnished by the kindness of Parke, Davis & Company.

SYNOPSIS OF THE DATA IN 25 CASES OF ACUTE INTESTINAL OBSTRUCTION EXCLUDING THOSE DUE TO NEOPLASMS

Case Number	Hospital Number, Initials, Age, Sex	Type of Lesion, Duration before Operation, Date of Operation, Anesthesia	Date and Time of Obtaining Blood	*Potassium in mg. % in* Whole Blood	Cells	Plasma	Cell Volume by Hematocrit	Plasma Specific Gravity	Plasma Protein	Other Data and Remarks	Result, Date of Discharge
				Average Values for Ten Healthy Donors							
				190	376	16.7	46.1%	1.0261	6.5%		
1.	85728 J. E. 59 yrs. Female	Strangulated incisional hernia. 5 days	9/24/36 2 P.M.	169	343	25.7	42 %	....	....	Ser. chlorides 565 mg.%; Bl. CO_2 61 cc./100; B.U.N. 13 mg./100 Intermittent type of obstruction. Treated conservatively 5 days by colon lavages, clyses of saline and glucose.	
	Index 6	9/29/36 Repair of hernia. G.-O.-E.								Location of lesion: Low ileum	Cured 10/24/36
2.	448691 S. L. 60 yrs. Male	Acute int. obstr. due to bands. 2½ days	9/26/36 11 A.M.	202	366	29.8	47 %	....	....	Case reported previously, ref. SURG., 1, 74, January, 1937.	
			10/17/36 7:30 A.M.	198	367	17.6	49 %	....	....	Location of lesion: Injected loop of lower ileum	
	Index 12	9/26/36 Jejunostomy. Spinal									
		9/28/36 Division of bands. Spinal									Cured 11/5/36
3.	368800 R. P. 37 yrs. Female	Acute int. obstr. due to peritoneal adhesions. 2 days	11/14/36 2 P.M.	196	347	29.1	48 %	1.0287	7.4%	R.B.C. 5,000,000; Hb. 85%; W.B.C. 17,400; P. 89%. Roentgen ray: Multiple fluid levels. Gastric and repeated colon lavages. No improvement in 12 hrs. Clysis 2,000 cc.	
	Index 2	11/15/36 Division of bands. Spinal	11/15/36 3:30 A.M.	180	364	23.0	43 %	1.0246	6 %	Taken after operation Peritoneal fluid was sanguineous.	
			11/16/36 7:10 A.M.	196	390	24.0	44 %	1.0257	6.4%	*Potassium content of centrifuged specimen 21.3 mg.%*	
			11/18/36 7:30 A.M.	157	366	21.5	37 %	1.0231	5.5%	Location of lesion: Cyanotic loop of ileum	Cured 11/29/36
4.	506308 A. C. 47 yrs. Female	Acute int. obstr. due to strangulated ventral hernia. 2 days	12/19/36 1:55 P.M.	207	332	27.3	54 %	1.0299	7.8%	W.B.C. 16,600; P. 85%; Roentgen ray: Fluid levels. Urine: Alb. H.T. Glu. 4+. Acetone 4+. Given 2,000 cc. Ringer's solution by infusion at oper. Peritoneal fluid sanguineous.	
			12/20/36 10:30 A.M.	172	352	20.4	43 %	1.0255	6.3%	*Potassium content after centrifuging 21.3 mg.%*	
		12/19/36 Relief of obstruction. Spinal	12/22/36 7:15 A.M.	154	375	18.9	36 %	1.0246	6 %	12/21/36: Bl. urea N. 21 mg./100 Bl. sugar 144 mg./100 Bl. sugar 153 mg./100	
			12/29/36 7:40 A.M.	174	356	20.9	43 %	1.0275	7 %	Location of lesion: dusky loop of ileum in sac	Cured 1/30/37
5.	506363 M. W.	Anemic infarct of terminal ileum and	12/23/36	228	365	13.4	59 %	1.0276	7 %	On admission: W.B.C. 13,500; P. 86%.	

			Spinal	12/29/36 7:15 A.M.							Bl. sugar 153 mg./100
				12/29/36 7:40 A.M.	174	356	20.9	43 %	1.0275	7 %	Location of lesion: dusky loop of ileum in sac — Cured 1/30/37
5.	506363 M. W. 53 yrs. Female	Anemic infarct of terminal ileum and cecum due to mesenteric thrombosis. 2 days	12/23/36 7:30 P.M.		228	365	13.4	59 %	1.0276	7 %	On admission: W.B.C. 13,500; P. 86%. Given 1,500 cc. of Ringer's solution
			10 P.M.		233	382	15.0	57 %	1.0301	7.9%	This blood was taken before operation and after the saline had been given
	Index 100	12/23/36 Resection of cecum and ileum. Primary anastomosis. Spinal	12/24/36 1:30 A.M.		198	334	21.5	53 %	1.0259	6.5%	At the end of operation, during which time 2,000 cc. of Ringer's solution intravenous
			8 A.M.		220	365	22.8	54 %	1.0262	6.6%	Continuous infusion of Ringer's solution running when this sample was obtained.
							Serum		Serum	Serum	
			12/25/36 9 A.M.				21.5		1.0234	5.6%	*Potassium content in resected loop after centrifuging: 591.6 mg.%*
			7 P.M.				20.2		1.0249	6.1%	Location of lesion: Cecum and terminal ileum
			12/26/36 9 A.M.				24.0		1.0237	5.7%	Autopsy: Extension of mesenteric thrombosis up the ileum — Died 12/26/36
6.	508585 V. F. 31 yrs. Female	Obstruction due to multiple postoperative adhesions.	1/16/37 3 P.M.		210	406	19.9	47 %	1.0303	8 %	On admission: W.B.C. 12,120; P. 95%; Hb. 105. Roentgen ray: "Fluid levels in ileum." Given hyperdermoclysis.
	Index 4	1 day 1/16/37	7 P.M.		210	457	18.1	42 %	1.0267	6.7%	This blood taken on operating table after spinal anesthesia and ephedrine had been given.
		Division of adhesions. Spinal	1/17/37 8 A.M.		172	329	20.8	46 %	1.0229	5.4%	*Peritoneal fluid K. 18.4 mg.% uncentrifuged. 17.5 mg.% centrifuged.*
			1/18/37 8 A.M.		163	388	19.6	37 %	1.0235	5.7%	Location of lesion: Lower ileum — Cured 2/1/37
7.	508670 G. L. 70 yrs. Male	Obstruction due to strangulated inguinal hernia. Richter's hernia of transverse colon.	1/20/37 9 P.M.		210	352	19.7	54 %	1.0272	6.9%	W.B.C. 14,600; P. 94%. Roentgen ray: Fluid levels. Barium enema showed obstruction in transverse colon
	Index 24	1 day	1/21/37 2 A.M.		192	332	19.6	52 %	1.0264	6.6%	Taken during operation but before 3,000 cc. of Ringer's solution had been given by infusion and clysis
		1/21/37 Relief of obstruction. Spinal	7:30 A.M.		184	340	17.5	49 %	1.0261	6.5%	Taken before clysis of 2,000 cc. of saline and glucose
			1/22/37 7:30 A.M.		170	318	20.4	47 %	1.0242	5.9%	Taken before clysis of 1,500 cc. of saline and 5% glucose
			2/3/37 7:30 A.M.		178	318	18.4	50 %	1.0275	7 %	Location of lesion: Transverse colon — Cured 2/6/37

(Continued on next page)

SYNOPSIS OF DATA (*continued*)

Case Number	Hospital Number, Initials, Age, Sex	Type of Lesion. Duration before Operation. Date of Operation. Anesthesia	Date and Time of Obtaining Blood	*Potassium in mg. % in* Whole Blood	Cells	Plasma	Cell Volume by Hematocrit	Plasma Specific Gravity	Plasma Protein	Other Data and Remarks	Result. Date of Discharge
8.	509097 W. C. H. 34 yrs. Male	Obstruction due to multiple postoperative adhesions. 2 days	2/8/37 1:30 P.M.	180	350	15.2	47 %	1.0304	8 %	W.B.C. 15,200; P. 88%.	
			6:55 P.M.	180	374	15.4	44 %	1.0289	7.5%	Taken after operation and before infusion of Ringer's solution	
	Index 18	2/8/37 Division of peritoneal bands. Spinal	8 P.M.	150	320	12.9	43 %	1.0258	6.4%	Taken after infusion	
			2/17/37 7:30 A.M.	137	335	19.8	35 %	1.0262	6.6%	Location of lesion: Lower ileum	Cured 2/23/37
9.	419165 L. P. Negro 29 yrs. Male	Obstruction due to band. Had been operated on for acute appendicitis with peritonitis 2½ yrs. previously.	2/17/37 4:45 P.M.	195	306	33.4	53 %	1.0379	10.6%	N.P.N. 55 mg.%; W.B.C. 18,700; P. 88%. Roentgen ray: "Fluid levels in ileum." B.P. 140/110	
			9:40 P.M.	201	334	23.7	53 %	1.0379	10.6%	Taken on operating table after spinal and ephedrine had been given and after incision	
	Index 12	4 days 2/17/37 Division of band. Enterostomy. Spinal G–O–E.	19:40 P.M.	183	330	18.3	50 %	1.0341	9.3%	Taken at the end of operation and after the administration of 1,500 cc. of Ringer's solution by infusion	
			2/18/37 8:10 A.M.	182	354	15.8	47 %	1.0238	5.8%	*Peritoneal fluid cloudy. Potassium content 15.9 mg.%* Continuous infusion running when blood was taken. Serum chlorides 585 mg.% Bl. urea N. 23 mg.%	
			2/19/37 7:30 A.M.	179	342	21.2	46 %	1.0283	7.3%	Continuous infusion running. Gastric suction stopped today. Enterostomy draining. *Potassium of enterostomy fluid 21.2 mg.%.* R.B.C. 4,000,000; Hb. 85%	
			2/20/37 7:30 A.M.	195	386	17.6	46 %	1.0258	6.4%	*Potassium of enterostomy fluid 18.0 mg.%*	
			2/24/37 7:30 A.M.	177	359	22.7	43 %	1.0264	6.6%	Ser. chlorides 515 mg.%; CO_2 56 Ml./100. cc. Enterostomy tube still draining	
			3/6/37 7:30 A.M.	176	382	16.0	42 %	1.0242	5.9%	Wounds practically healed. Up in chair Location of lesion: Lower ileum	Cured 3/12/37
10.	258815 G. L. 35 yrs. Negress	Obstruction due "large inflamed sheath of tissue where the broad ligament had been united at a previous operation 27 days ago." 2 days	2/19/37 2:30 P.M.	163.4	438	19.1	33 %	1.0318	8.5%	R.B.C 4,120,000; Hb. 70%; W.B.C. 7,900; P. 58%; N.P.N. 28.7 mg.%; ser. chlorides 563 mg.%. Roentgen ray: "Gaseous distended loops of colon with multiple fluid levels"	
	Index 10		2/20/37 7:30 A.M.	146	286	23.2	43 %	1.0267	6.7%	Colostomy has not been opened. Patient very restless. Pulse 160; temp. 104°. Has	

	35 yrs. Negress	large inflamed sheath of tissue where the broad ligament had been united at a pre-	2:30 P.M.							563 mg.%. Roentgen ray: "Gaseous distended loops of colon with multiple fluid levels"	
	Index 10	vious operation 27 days ago." 2 days	2/20/37 7:30 A.M.	146	286	23.2	43 %	1.0267	6.7%	Colostomy has not been opened. Patient very restless. Pulse 160; temp. 104°. Has had 3,000 cc. of saline and 5% glucose by clysis and infusion	
		2/19/37 Colostomy. Spinal	3/17/37 7:45 A.M.	182	486	21.3	33 %	1.0276	7 %	Up in chair today. Colostomy functioning	
										Location of lesion: Sigmoid	
										To return for closure of colostomy later	Relieved 4/5/37
11.	512603 B. C. 70 yrs. Female	Obstruction due to strangulated femoral hernia. 2 days	3/9/37 4:50 P.M.	190	348	19.7	49 %	1.0294	7.7%	W.B.C. 12,700; P. 89%; B.P. 150/100. Before operation given 1,500 cc. of 5% glucose in Ringer's solution. Ser. chlorides 565 mg.%; Bl. CO_2 50 Ml./100 cc. *Potassium content of spinal fluid 15.3 mg.%.*	
	Index 6	3/9/37 Reduction of strangulated hernia with imbrication.	9 P.M.	184	342	19.4	48 %	1.0295	7.7%	At the end of operation. *Potassium content of peritoneal fluid 12.5 mg.%*	
		Spinal	3/14/37 8:15 A.M.	189	450	13.2	39 %	1.0257	6.4%	Has had 80 Gm. of NaCl and 14,000 cc. of fluid since last blood sample	Cured 3/27/37
12.	399137 J. R. 72 yrs. Male	Strangulated left indirect inguinal hernia	4/14/37 4:15 P.M.	222	373	20.4	54 %	1.0304	8 %	Admitted to medical ward. Diagnosis: Coronary? W.B.C. 14,950; P. 87%; R.B.C. 6,840,000; Hb. 105%. Sp. gr. of blood: 1.0598; B.P. 120/80. Electrocardiogram: T wave changes either due to myocardial damage or digitalis medication. Has had 2,000 cc. of saline and 5% glucose by clysis. Second blood taken after spinal and before infusion	
			7:25 P.M.	233	421	17.5	51 %	1.0286	7.4%		
	Index 24	2 days	4/15/37 8 A.M.	250	487	16.1	49 %	1.0278	7.1%		
		4/14/37	4/16/37 8 A.M.	222	427	15.7	48.5%	1.0291	7.6%		
		Reduction of strangulation; repair of hernia	4/17/37 8 A.M.	216	404	14.3	50 %	1.0280	7.2%	*Potassium content of peritoneal fluid 28.6 mg.%*	
			4/19/37 8 A.M.	205	383	15.7	49.5%	1.0288	7.5%	*Potassium content of spinal fluid at operation 14.7 mg.%*	
		Spinal								Stay in hospital prolonged due to acute cystitis following retention of urine due to benign hypertrophy of prostate. Location of lesion: Ileum	Cured 5/10/37
13.	516211 M. B. 65 yrs. Male	Strangulated rt. direct inguinal hernia 6 hrs.	4/27/37 2:15 P.M.	226	427	20.4	48 %	1.0287	7.4%	No saline given before operation. B.P. 170/98. 1,500 cc. of saline given by clysis postoper.	
		4/27/37	4/28/37 8 A.M.	172	356	18.6	43 %	1.0250	6.2%		
	Index 8	Relief of strangulation; repair of hernia	4/30/37 8 A.M.	175	420	14.5	38 %	....	....	Has had 6,000 cc. of saline by clysis since last blood analysis	
			5/1/37 8:30 A.M.	161	360	15.2	40.5%	1.0237	5.7%	Has had 1,500 cc. of saline by clysis since last blood analysis	

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SYNOPSIS OF DATA (*continued*)

Case Number	Hospital Number, Initials, Age, Sex	Type of Lesion. Duration before Operation. Date of Operation. Anesthesia	Date and Time of Obtaining Blood	*Potassium in mg.% in* Whole Blood	Cells	Plasma	Cell Volume by Hematocrit	Plasma Specific Gravity	Plasma Protein	Other Data and Remarks	Result. Date of Discharge
		Spinal	5/6/37 7:50 A.M.	229	484	17.2	44.1%	1.0266	6.7%	Developed bronchopneumonia May 2	
			5/7/37	182	344	18.1	47.5%	1.0262	6.6%	Temperature normal. Location of lesion: Low ileum	Cured 5/20/37
14.	312208 J.S.G. 42 yrs. Female	Strangulated postoperative ventral hernia	5/15/37 1:40 P.M.	185	383	16.9	43.9%	1.0298	7.8%	W.B.C. 12,250; P. 88%; N.P.N. 43 mg.%; CO_2, 64 Ml./100 cc.. Specific gravity of whole blood 1.0583. B.P. 118/70. *Potassium content of peritoneal fluid 18.5 mg.%*	
			4:30P.M.	202	424	15.4	44 %	1.0307	8.1%	Sample taken during operation before infusion. Culture of peritoneal cavity: *B. coli.*	
		2 days 5/15/37	6:30 P.M.	186	390	17.4	43.3%	1.0265	6.6%	At end of operation after infusion 1,000 cc. saline but before transfusion of whole blood. *Potassium content of gangrenous gut 637 mg.%*	
			6:50 P.M.	191	368	19.0	46.6%	....	....	After transfusion of 500 cc. of blood	
	Index: no data	Resection of gangrenous ileum: primary end-to-end anastomosis G.-O.-E.	5/16/37 7:50 A.M.	183	387	20 7	41.8%	1.0261	6.5%	Has had 2,000 cc. of saline intravenously since last analysis. Nasal suction by Wangensteen tube all night. *Potassium content of gastric fluid 42.4 mg.%.*	
		Autopsy: Bilateral bronchopneumonia. Extension of gangrene of ileum. Leakage of site of anastomosis with peritonitis. Infection of wound	5/17/37 7:50 A.M.	158	390	12.5	37.5%	1.0259	6.4%	Has had 3,000 cc. of saline intravenously since last analysis. Total amount of NaCl since admission 67 Gm. Signs of pneumonia. Temp. 102°	
			5/18/37 7:50 A.M.	174	447	13.5	35.9%	1.0266	6.7%	Has had 2,500 cc. more saline intravenously by continuous drip. Ser. chlorides 624 mg.%. Blood urea nitrogen 9 mg.%;	
		Note: At operation the strangulated loop had ruptured; local peritonitis	3:05 P.M.	145	366	13.2	36 %	1.0257	6.4%	CO_2 39 Ml./100 cc., before transfusion	
			4:10 P.M.	170	394	16.3	39 %	1.0258	6.4%	10 min. after transfusion of 500 cc. of blood. Placed in oxygen tent	
			5/21/37 8:20 A.M.	148	347	13.0	39 %	1.0261	6.5%	Ser. chlorides 672 mg.%. Blood urea N. 7 mg.%; CO_2 49 Ml./100 cc. Blood culture: No growth. Temp. 106°, pulse 140, resp. 36	
			4:40 P.M.	186	384	13.8	44.7%	1.0267	6.7%	This sample taken after transfusion and 16 hrs. before death. The patient went into shock the following morning and died with temp. of 107.2°. Location of lesion: Terminal ileum	Died 5/22/37
15.	445205 G. R.	Strangulated rt. femoral hernia	5/20/37 1 P.M.	178	336	21.3	46.6%	1.0289	7.5%	No saline given before operation. B.P. 128/80. This sample obtained on oper-	

			Terminal ileum								5/22/37
15.	445205 G. R. 68 yrs. Male	Strangulated rt. femoral hernia	5/20/37 1 P.M.	178	336	21.3	46.6%	1.0289	7.5%	No saline given before operation. B.P. 178/80. This sample obtained on operating table before infusion	
		1 day	5/21/37 8 A.M.	228	480	16.5	44.2%	1.0238	5.8%	Has had 2,000 cc. of saline since last blood sample	
	Index: No data	5/20/37 Relief of strangulation; repair of hernia Local	5/24/37	188	332	17.3	51.6%	1.0271	6.9%	Nonprotein nitrogen 47 mg.%. Doing well Location of lesion: Ileum	Cured 6/4/37
16.	436642 R. G. 39 yrs. Female	Obstruction due to postoperative adhesions about which there was a volvulus Hysterectomy 1934	5/21/37 1 P.M.	180	335	15.9	49 %	1.0310	8.2%	W.B.C. 10,200; P. 77%. Roentgen ray: Fluid levels in ileum. Sp. gr. blood 1.0624. CO_2 combining power 75.3%; N.P.N. 37 mg.% Infusion of saline and 5% glucose given before operation.	
		5 days	6 P.M.	166.7	346	13.5	44.4%	1.0274	7 %	Blood sample taken on operating table after infusion. Second infusion 1,000 cc. saline and 300 cc. 5% NaCl. *Potassium content of peritoneal fluid 13.2 mg.%*	
	Index 12	5/21/37 Division of peritoneal bands. Ileotomy	5/22/37 7:30 A.M.	145	332	15.4	39 %	1.0266	6.7%	Ser. chlorides 624 mg.%. Blood urea nitrogen 16 mg.%. CO_2 51 Ml./100 cc. Continuous infusion and gastric suction since operation. *Potassium content of gastric fluid 65.8 mg.%* Has had 4,560 cc. of saline since admission	
		Spinal	5/23/37 7:40 A.M.	134.2	320	13.1	38 %	1.0260	6.5%	Has had 2,000 cc. more of saline intravenously. Gastric suction stopped last night	
			5/24/37 7:20 A.M.	121	324	14.1	32.9%	1.0245	6 %	R.B.C. 3,820,000; Hb. 61%; W.B.C. 5,200; P. 73%. Given transfusion	
			5/27/37 8 A.M.	147	328	25.3	37.2%	1.0261	6.5%	Location of lesion: Low ileum	
			6/3/37 8:30 A.M.	166	382	19.4	38.5%	....	....		Cured 6/19/37
17.	524151 M. McD. 46 yrs. Female	Obstruction due to incisional hernia. Distention 4 hrs. Attacks of cramp-like pain 1 wk.	8/2/37 9:15 P.M.	192	373	20.1	46 %	1.0272	6.9%	Obese, florid patient. Given spinal anesthesia. Died on table. B.P. 200/98 before operation. Patient was extremely nervous and apprehensive. Gas-oxygen administered before spinal puncture. Became cyanotic. On admission, sp. gr. of blood 1.0572. W.B.C. 9,600; P. 63%. Urine: Glucose 4+, alb. 1+	
	Index 2	8/2/37 Spinal									Died 8/2/37

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SYNOPSIS OF DATA (*continued*)

Case Number	Hospital Number, Initials, Age, Sex	Type of Lesion. Duration before Operation. Date of Operation. Anesthesia	Date and Time of Obtaining Blood	*Potassium in mg. % in* Whole Blood	Cells	Plasma	Cell Volume by Hematocrit	Plasma Specific Gravity	Plasma Protein	Other Data and Remarks	Result. Date of Discharge
18.	456262 F. L. 59 yrs. Female	Obstruction due to strangulated umbilical hernia.	9/16/37 12:10 A.M.	162	302	15.3	48.4%	1.0264	6.6%	Sp. gr. whole blood 1.0556. CO_2 36 vol.%. Ser. chlorides 496 mg.%. Bl. sug. 386 mg.%. After 1,000 cc. of infusion R.B.C. 4,400,000; Hb. 96%; W.B.C. 11,600; P. 88%	
		1½ days	1:15 A.M.	192.3	387	17.2	45.4%	1.0239	5.8%	Preop. sample after infusion	
	Index 20	9/16/37	7:50 A.M.	139.4	296	12.3	43 %	1.0235	5.7%	CO_2 39 vol. %. Bl. urea N. 19 mg.%; bl. sug. 316 mg.% *Potassium content of gastric suction 34.2 mg.%*	
		Reduction of hernia with repair	1:45 P.M.	167	378	12.1	40.9%	1.0222	5.2%	Before transfusion of 500 cc. of blood: Sug. 153 mg.%	
			2:45 P.M.	167	366	12.3	42.1%	1.0232	5.5%	5 min. after transfusion: Ser. chlorides 560 mg.%. Given 2,000 cc. of Hartmann's solution	
		Local	9/17/37 8:30 A.M.	165	352	11.2	43.6%	1.0225	5.3%	CO_2: 49 vol.%. Ser. chlorides 542 mg.%. Bl. sug. 124 mg.%	
			9/18/37 8 A.M.	172	371	10.4	43.6%	1.0222	5.2%	CO_2: 56 vol.%. Ser. chlorides 542 mg.%	
			10/9/37 7:40 A.M.	191	386	16.2	45.2%	1.0263	6.6%	Blood sug. 117; diabetes controlled. C. 100. P. 60-F. 50. 35 units of protamine insulin	Cured 10/21/37
19.	530547 L. H. 40 yrs. Female	Obstruction due to strangulated femoral hernia	9/30/37 5:30 P.M.	225	371	23.5	54.4%	1.0305	8 %	W.B.C. 22,500; P. 93%; R.B.C. 6,930,000; Hb. 128%. Sp. gr. of blood 1.0600. Given 2,000 cc. of Ringer's. Urine: Alb. 0, acetone 0. *Potassium in vomitus 46.1 mg.%*	
		19 hrs. 9/30/37	8 P.M.	186	368	16.5	46 %	1.0290	7.5%	Before operation but after infusion. Gastric suction started after operation. Given second infusion postop. of 1,500 cc. of Ringer's	
	Index 45	Reduction of hernia, with repair	10/1/37 7:50 A.M.	153	340	14.7	40.8%	1.0230	5.5%	CO_2 44 vol.%. Ser. chlorides 644 mg.%. Given two clyses 3,000 cc. of dextrose and Ringer's *Potassium content of peritoneal fluid 17.2 mg.%*	
			10/2/37 6:30 A.M.	147	282	21.3	44.5%	1.0267	6.7%	CO_2 43 vol.%. Ser. chlorides 592.	
		Spinal	10/8/37 8 A.M.	150	347	18.3	38 %	1.0252	6.2%	Oct. 6, Bl. urea N. 6 mg.% Smooth postoperative course.	
			10/25/37 8:30 A.M.	174	382	17.2	41 %	1.0255	6.3%	Location of lesion: Low ileum	Cured 10/25/37
20.	408044 F. O. 52 yrs.	Obstruction due to strangulated femoral hernia. Cramp-like	10/1/37 3:10 P.M.	157	321	27.8	40.2%	1.0293	7.6%	Patient with mitral and aortic stenosis and insufficiency admitted for bronchopneumonia Type III. Developed hernia due to	

			8 A.M. 10/25/37	150	347	18.3	38 %	1.0252	6.2%	Smooth postoperative course. Location of lesion: Low ileum — Cured 10/25/37
			8:30 A.M.	174	382	17.2	41 %	1.0255	6.3%	
20.	408044 F. O. 52 yrs. Male	Obstruction due to strangulated femoral hernia. Cramp-like pain 65 hrs. Vomiting 3 hrs.	10/1/37 3:10 P.M.	157	321	27.8	40.2%	1.0293	7.6%	Patient with mitral and aortic stenosis and insufficiency admitted for bronchopneumonia Type III. Developed hernia due to excessive coughing. Bl. chlor. 572 mg.%. CO_2 70 vol.%; B.P., 4 hrs. postop. 115/85.
			6:30 P.M.	158	287	30.1	44.5%	1.0268	6.8%	Sample taken after operation. Patient placed in oxygen room. Given infusion 1,500 cc. of Ringer's and 20 cc. of eschatin. Venous pressure before infusion 72 Mm.
	Index 72	10/1/37 Resection of gangrenous Richter's type of hernia. End-to-end anastomosis. Local and avertin	10/2/37 4:45 A.M.	..	..	21.3	37.8%	1.0283	7.3%	Went into shock 6 hrs. postop. 50% glucose intravenously plus 20 cc. of eschatin and indirect transfusion 300 cc. Profuse sweating. B.P. 40/0. Pulse 170. Gastric suction functioned well. Abd. soft. Infusion continued with 5% glucose and normal saline. 40 cc. of eschatin, N.P.N. 51 mg.%; ser. chlorides 614 mg.%; CO_2 50 vol.% 7 A.M. N.P.N. 77 mg.%; ser. chlorides 600 mg.%; CO_2 50 vol.% 7 P.M. During 20 hrs. before death, the twitching of various muscle groups with carpopedal spasm on applying tourniquet was very striking. 24 cc. of digalen and two injections of 50% sucrose during 12 hrs. *Potassium content of resected loop fluid 109 mg.%* *Potassium content of gastric suction fluid 38.1 mg.%* *Potassium content of urine 450 mg.%* Location of lesion: Low ileum (See chart for further details) — Died 10/2/37
			7:15 A.M.	151	322	26.2	38.8%	1.0291	7.5%	
			2:15 P.M.	154	319	32.3	38.1%	1.0289	7.5%	
			7 P.M.	156	339	31.1	36.8%	1.0282	7.2%	
			Autopsy: Rheumatic endocarditis of mitral and aortic valves. Mitral stenosis and insufficiency. Aortic stenosis and insufficiency. Cardiac hypertrophy and dilatation. Lobular pneumonia. Chronic passive congestion of lungs. Peritoneal abscess localized. Amebic abscess of liver, obsolete. Fibrous pleural and peritoneal adhesions							

FIVE CASES IN WHOM THE INITIAL BLOOD WAS TAKEN AFTER TREATMENT OR OPERATION

21.	463086 B. S. 17 yrs. Female	Obstruction due to postoperative adhesions. 4½ days	2/8/37 3:20 P.M.	161	351	15.1	41.5%	1.0227	5.4%	Patient admitted 2/5/37 with tentative diagnosis of acute cholecystitis. Under observation for 3 days during which time she received two infusions of saline and 5% glucose and 1,000 cc. of Ringer's solution by clysis. The initial potassium determination done on blood taken before operation. Roentgen ray: Fluid levels.
	Index on admission: 8. Before operation: 8	2/8/37 Division of adhesions. G.-O.-E.	7:40 P.M.	187	360	14.5	48 %	1.0232	5.5%	Taken at the close of operation
			2/10/37 4:15 P.M.	148	309	17.9	42 %	1.0211	4.8%	*Potassium in peritoneal fluid 16.3 mg.%* Roentgen ray: Pneumonia of rt. lung. Has had 5,000 cc. of saline by infusion and clysis since last blood determination. Gastric suction for two days
			2/24/37 7:40 A.M.	172	374	18.1	41 %	....	....	Location of lesion: Lower ileum — Cured 2/24/37

(*Continued on next page*)

SYNOPSIS OF DATA (*continued*)

Case Number	Hospital Number. Initials, Age, Sex	Type of Lesion. Duration before Operation. Date of Operation. Anesthesia	Date and Time of Obtaining Blood	*Potassium in mg. % in* Whole Blood	Cells	Plasma	Cell Volume by Hematocrit	Plasma Specific Gravity	Plasma Protein	Other Data and Remarks	Result. Date of Discharge
22.	359290 J. W. 64 yrs. Female	Obstruction due to postoperative adhesion causing gangrene of jejunum.	1/7/37							Admitted with diagnosis of obstruction due to impacted feces in colostomy stoma R.B.C. 5,010,000; Hb. 95%; W.B.C. 27,760; P. 95% *Potassium content of fluid above obstruction 147 mg. %*	
	Index on admission: 16. Before operation: 63	24 hrs. 1/8/37 Resection of jejunum, end-to-end anastomosis. Contamination due to spilling of intestinal contents. Wound left open and treated with zinc peroxide. Spinal	1/8/37 9:30 A.M.	172	400	16.6	39 %	1.0267	6.7%	This blood was taken at the end of operation and after the patient had received 4,800 cc. of Ringer's solution and 5% glucose *Potassium content of gastric suction 52.3 mg. %*	
			11:45 A.M.	174	384	16.3	41 %	1.0243	5.9%	Before transfusion	
			12:05 P.M.	178	366	20.6	43 %	1.0261	6.5%	After transfusion 600 cc. of whole blood	
			1/9/37 7:30 A.M.	179	370	19.7	43 %	1.0246	6 %	Continuous infusion running. B.U.N. 21 mg. % *Potassium content of gastric suction: 61.6 mg.%*	
			1/11/37 8 A.M.	166	420	14.9	36 %	1.0236	5.7%	Has had 10,000 cc. of saline since last sample *Potassium content of gastric suction 35.1 mg.%* R.B.C. 3,820,000; Hb. 68%	
		Wound culture: Hem. and nonhem. strep. Gram-positive rods. *B. coli*	1/12/37 4 P.M.	152	403	15.1	34 %	1.0239	5.8%	Before transfusion *Potassium content of gastric suction 19.5 mg.%*	
			4:20 P.M.	160	395	21.1	35 %	1.0293	7.6%	After transfusion of 500 cc. of whole blood	
			1/14/37 8:20 A.M.	163	410	15.5	36 %	1.0223	5.2%	Gastric suction and continuous infusion discontinued.	
			1/15/37 8:30 A.M.	142	315	12.3	41 %	1.0284	7.3%	Running a temperature of about 2 degrees; sloughs separating from wound	
			1/18/37 8 A.M.	134	360	10.0	34.5%	1.0267	6.7%	January 19. R.B.C. 3,500,000; Hb. 52%	
			1/20/37 8 A.M.	115	312	8.7	34 %	1.0240	5.8%	Running septic temperature	
			1/23/37 3:30 P.M.	125	454	16.2	24 %	1.0247	6 %	Before transfusion	
			4 P.M.	114	321	17.5	30 %	1.0258	6.4%	5 minutes after transfusion of 668 cc. of whole blood	
			1/28/37							R.B.C. 2,700,000; Hb. 42%; W.B.C. 17,300; P. 85%. Serum chlorides 566 mg.%;	

			3:30 P.M.	123	434	16.2	24 %	1.0247	6.4%	Blood transfusion
			4 P.M.	114	321	17.5	30 %	1.0258	6.4%	5 minutes after transfusion of 600 cc. of whole blood
			1/28/37							R.B.C. 2,700,000; Hb. 42%; W.B.C. 17,300; P. 85%. Serum chlorides 566 mg.%; blood urea N. 88 mg.%
			1/29/37							Given transfusion of 800 cc. of whole blood. One hour later suddenly became cyanotic and died 3½ hrs. later. Death attributed to possible anaphylactic reaction Location of lesion: Jejunum
										Died 1/29/37
23.	433160 W. P. 80 yrs. Male Index: 20	Obstruction due to multiple peritoneal adhesions. 4 days 2/2/37 Division of peritoneal adhesions. Enterostomy. Spinal	2/2/37	....	....	....	....	Specific gravity of whole blood.	....	W.B.C. 15,100; P. 75%. Roentgen ray: Multiple fluid levels. Given 4,000 cc. of saline and 5% glucose by clysis. Went into shock 10 hrs. after operation
			2/3/37 4:20 P.M.	191	325	28.2	50 %	1.0597 (4:10 P.M.) 1.0500 (4:20 P.M.)		Venous pressure 65 Mm. of water at 3:30 P.M. No blood could be obtained from the vein as the patient was in collapse. 300 cc. of 5% NaCl administered after which the blood was secured for analysis. This blood obtained after 300 cc. more of 5% saline.
			4:45 P.M.	182	352	23.9	45 %			
			6:40 P.M.	....	....	....	....	1.0567		Venous pressure 140 Mm. of water at start of transfusion. After 200 cc. of blood, 120 Mm. of water. After 200 cc. more of blood, 175 Mm. of water. Hence no more blood given. Died 9 hrs. later Autopsy: Peritonitis Location of lesion: Middle and lower ileum
										Died 2/4/37
24.	514139 L. A. D. 64 yrs. Male	Strangulated femoral hernia. Richter's type. 2 days 4/8/37 Resection of small intestine, with primary anastomosis. Spinal	4/12/37 9:30 A.M.	192	490	15.5	36 %	1.0232	5.5%	W.B.C. 9,700; P. 82% with "shift to left." Roentgen ray: Fluid levels. By the time the first blood analysis was made the patient had received: 17,000 cc. of saline solution by infusion and clysis. Equivalent to 168 Gm. of salt. Bl. Urea N. 4/10/37, 27 mg.%. Gastric suction maintained 4 days postoper. Serum chlorides 700 mg.%; CO_2 48 Ml./100. Given transfusion of 600 cc. of whole blood at 11:30 A.M. This analysis before procedure.
			11:20 A.M.	202	509	16.3	36.5%	1.0238	5.7%	*Potassium in gastric contents 45.0 mg.%*
			11:45 A.M.	195	448	15.6	40 %	1.0262	6.6%	Blood sample taken after transfusion. Placed in oxygen tent. Roentgen ray: "Confluent bronchopneumonia both lungs." Blood culture neg.
			4/14/37 8:30 A.M.	222	482	15.1	43 %	1.0229	5.4%	Fluid intake since admission: 26,400 cc. Bilateral pitting edema of legs. Blood urea N. 13 mg.%. Parenteral fluids stopped.

(Continued on next page)

SYNOPSIS OF DATA (*continued*)

Case Number	Hospital Number. Initials, Age, Sex	Type of Lesion. Duration before Operation. Date of Operation. Anesthesia	Date and Time of Obtaining Blood	*Potassium in mg. % in* Whole Blood	Cells	Plasma	Cell Volume by Hematocrit	Plasma Specific Gravity	Plasma Protein	Other Data and Remarks	Result. Date of Discharge
										Urine: Sp.gr. 1.035, neg. for alb., gluc. R.B.C. 4,960,000; Hb. 95% (April 16)	
			4/17/37 8:30 A.M.	170	352	11.5	45 %	1.0240	5.8%	Edema of lower extremities less. Still in oxygen tent. Removed from tent in afternoon	
			4/22/37 8:15 A.M.	202	376	21.4	48 %	1.0233	5.6%	Afebrile today. On regular diet. Blood sample taken 10 min. after breakfast	
			5/6/37 8 A.M.	172	430	18.8	35.6%	1.0244	6 %	Discharged home today. Location of lesion: Middle ileum?	Cured 5/6/37
25.	527974 V. W. 16 yrs. Female	Volvulus of small intestine. 36 hrs.								Admitted for recurrent attacks of abdominal, cramp-like pain, vomiting and distention with diagnosis of appendicitis. Appendicectomy August 5, 1937. Normal appendix and some free fluid. Pain, vomiting and distention persisted. R.B.C. 6,000,000; Hb. 98%; sp. gr. of blood 1.0577. *Potassium content of gastric suction 46.9 mg.%*	
	Index: 30	8/9/37 Jejunostomy after reduction of volvulus. Spinal supplemented by G.-O.-E.	8/9/37 1:45 P.M.	213	430	16.5	45.7%	1.0266	6.7%		
			6 P.M.	170	318	15.5	48.7%	1.0248	6.1%	This sample after infusion, operation and transfusion. *Potassium content of intestinal fluid 32.7 mg.%* *Potassium content of peritoneal fluid 17.4 mg.%*	
			8/11/37 8 A.M.	143	316	13.1	40.9%	1.0239	5.8%	Kept in oxygen tent for 2 days. Gastric suction maintained for 5 days. *Potassium content of gastric suction 49.7 mg.%*	
			8/12/37 10 A.M.	159	361	13.1	40.4%	....	....	CO_2 51 vol. %. Ser. chlorides 602 mg.% *Potassium content of enterostomy drainage 26.9 mg.%* *Potassium content of gastric suction 18.5 mg.%*	
			8/17/37 8 A.M.	160	374	12.4	39.5%	1.0238	5.8%	Bl. Urea N. 6 mg. %. *B. coli* infection of wound	
			9/1/37 8 A.M.	170.3	364	14.2	43 %	1.0269	6.8%	Enterostomy tube removed 14 day. Discharged today. Average fluid intake for first week: 4,600 cc. a day. Average daily sodium chloride 35 Gm.	
										Location of lesion: Twist at upper and lower ileum	Cured 9/1/37

obstruction, hemorrhage into the loop, and tissue necrosis together with inadequate excretion.[107] Analysis of gangrenous loop fluid in four (Cases 5, 14, 20, and 22) revealed potassium content many times that of plasma, whereas, normally, the potassium content of succus entericus is the same as that of the plasma.[20, 128]

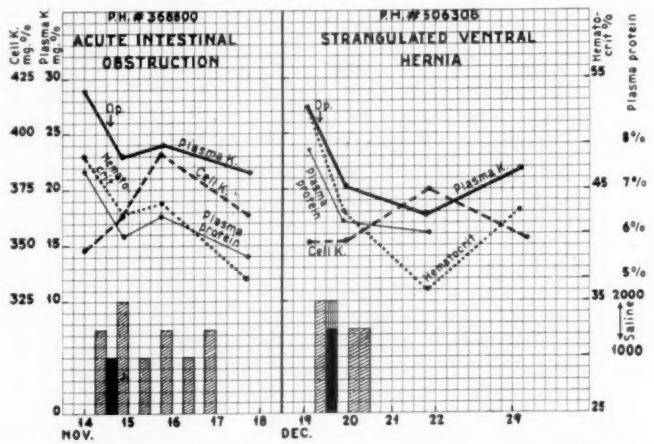

CHART 7.—Ordinates: Days. Abscissas: Plasma and cell potassium plasma protein and hematocrit readings. At bottom of chart the amount of fluid administered parentally is indicated. Solid black represents intravenous Ringer's solution; slanting lines Ringer's solution by clysis. See Cases 3 and 4 for details. Note the fall in plasma potassium and the rise in cell potassium after the administration of saline solution. Blood dilution is indicated by the fall in the hematocrit readings and plasma protein. Recovery in both cases.

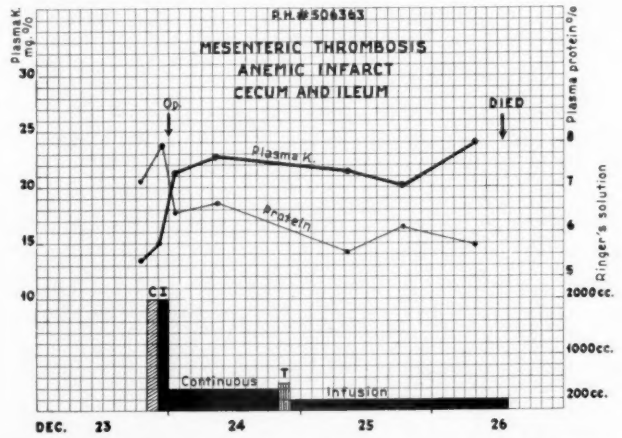

CHART 8.—Case 5. Ordinates: Days. Abscissas: Plasma potassium and plasma protein. In spite of the administration of saline solution the plasma potassium continued to rise. Autopsy showed extension of the gangrenous process.

A resection of the gangrenous loop with a primary anastomosis gave the best results in the moderately toxic patient[58] (Chart 6), probably for the following reasons: (1) The exclusion of the danger of perforation; (2) the elimination of infection; (3) the removal of the necrotic portion of the intestine with its abnormally high potassium content; (4) the maintenance of the

continuity of the gastro-intestinal tract with its base and fluid conserving function.

Enterostomy.—In this series, a primary enterostomy with the relief of obstruction measurably increased the mortality rate (Chart 5). Its surgical

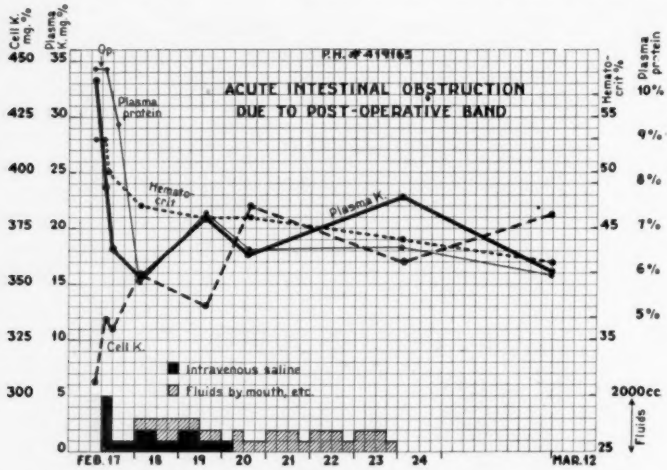

CHART 9.—Case 9. Ordinates: Days. Abscissas: Plasma and cell potassium, plasma protein and hematocrit readings. With the administration of saline solution the blood dilution is indicated by the fall in plasma protein and hematocrit readings. Plasma potassium fell and the cell potassium rose.

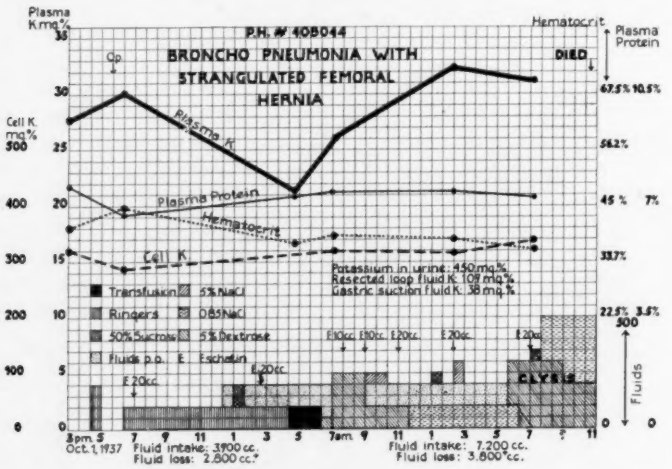

CHART 10.—Case 20. Ordinates: Time in hours. Abscissas: Plasma and cell potassium, plasma protein and hematocrit readings. At bottom of chart the types and amounts of fluids administered are detailed. In estimation of the fluid loss, 1,500 cc. were allotted to insensible perspiration. See case report for details.

merits have been controversial.[28, 65, 82, 111, 122, 124] Haden and Orr,[41] Dragstedt,[25] and Morton and Pearse[86] have shown that animals with intestinal fistulae died with the same manifestations of toxemia, and as soon as animals with obstruction at the same level. We have investigated the effect of complete intestinal fistulae upon both hemoconcentration and blood potassium and

find the resultant hyperpotassemia similar to that occurring in acute intestinal obstruction, [107, 108] experimental adrenal insufficiency, [123, 137] and experimental potassium poisoning.[139]

The 70 per cent mortality following enterostomy *without* the removal of the lesion (Chart 5) may thus be explained by two factors: (1) In failing to remove the obstruction, absorption of fluids and intestinal secretions is prevented; (2) the external loss of fluids and electrolytes through a fistula placed above the obstruction accentuates the dehydration with consequent earlier and greater rise in blood potassium.[108]

Enterotomy.—This was performed in 63 cases with a gross mortality of 57 per cent. Comparing this group with the relief of obstruction and enterostomy, the mortality in the latter is 9 per cent higher and the recovery rate is less at each index (Chart 5). This contrasts with Holden's[52] success, ob-

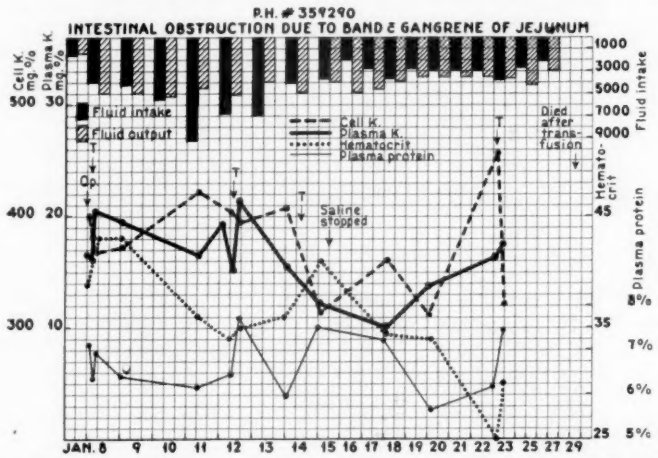

CHART 11.—Case 22. Ordinates: Days. Abscissas: Plasma and cell potassium, plasma protein and hematocrit readings. Daily fluid balance is indicated at top of chart. T indicates transfusion. Note the fall in cell potassium following each transfusion, also the increase in plasma proteins.

tained by relieving the obstruction, removing the intestinal content by stripping through an enterotomy, and the giving of hypertonic salt solution subcutaneously. His procedure eliminates the toxic intestinal fluid (rich in potassium); preserves the continuity of the gastro-intestinal tract and combats a potential hyperpotassemia by the *adequte administration of salts and fluids.* In our series, the gut was stripped in only two cases. More chemical studies on both the blood and intestinal contents are needed in this controversy of enterotomy *versus* enterostomy.[16, 62, 85, 87, 90, 115] Continued gastric suction has reduced the need for either.[78, 95, 126]

Gastric Lavage.—Introduced by Kussmaul[59] in the treatment of intestinal obstruction, gastric lavage is a recognized procedure. The advent of continued gastric suction has carried the value of decompression one step farther. Carlson[13] suggested some noxious element was washed out by vomiting. In our experimental work, the abnormally high potassium content of the vomitus indicates that secretion of this base into the gastric lumen, followed by vomit-

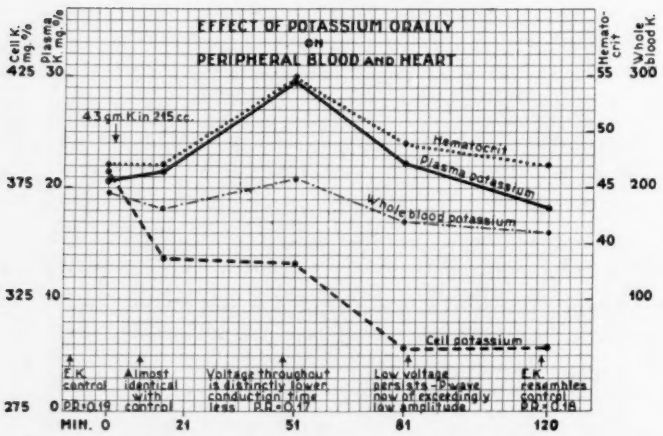

CHART 12.—Ordinates: Time in minutes. Abscissas: Hematocrit readings: Whole blood, plasma and cell potassium. A summary of the electrocardiographic data is to be found at the bottom of the chart.

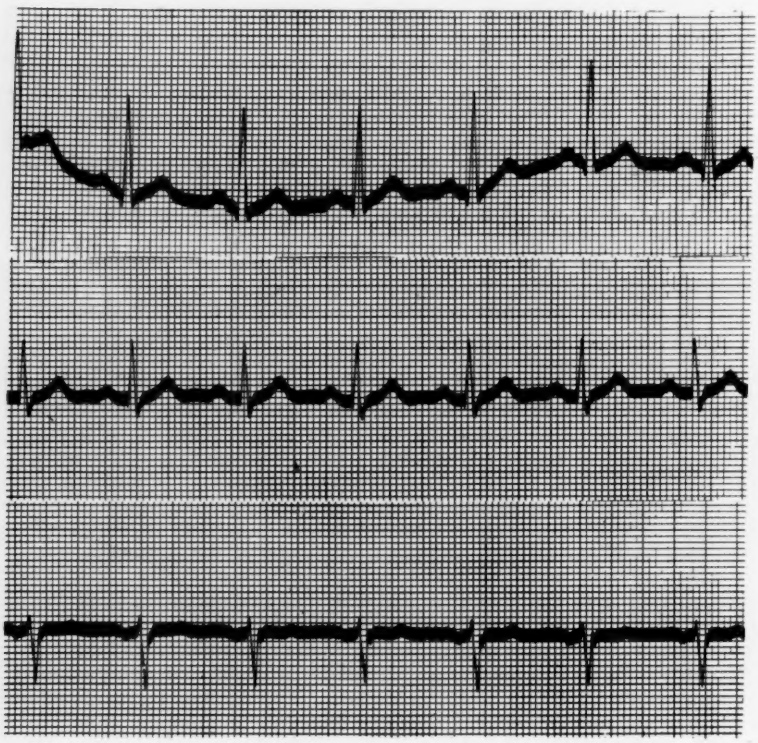

CHART 13.—Electrocardiographic Report: Leads 1, 2 and 3. Taken September 8, 1936. Control: Sinus rhythm. Ventricular rate 80 P–R = 0.17 to 0.19. Left preponderance. P_3 inverted. T1, T2, T3 upright. Well-marked left preponderance is the chief finding.

ing, may be regarded as part of an auxiliary or emergency mechanism for lowering blood potassium.[34, 54, 107, 108] The values are reported in eight cases.

Pulse in Obstruction.—The slow pulse is often deceptive. Eisberg[29] counsels against delaying operation until disturbances in the pulse become manifest.

The action of potassium on the heart both *in vivo* and *in vitro* has been amply demonstrated.[12, 22, 37, 53, 73, 79] Gautrelet[35] introduced into frogs' circul-

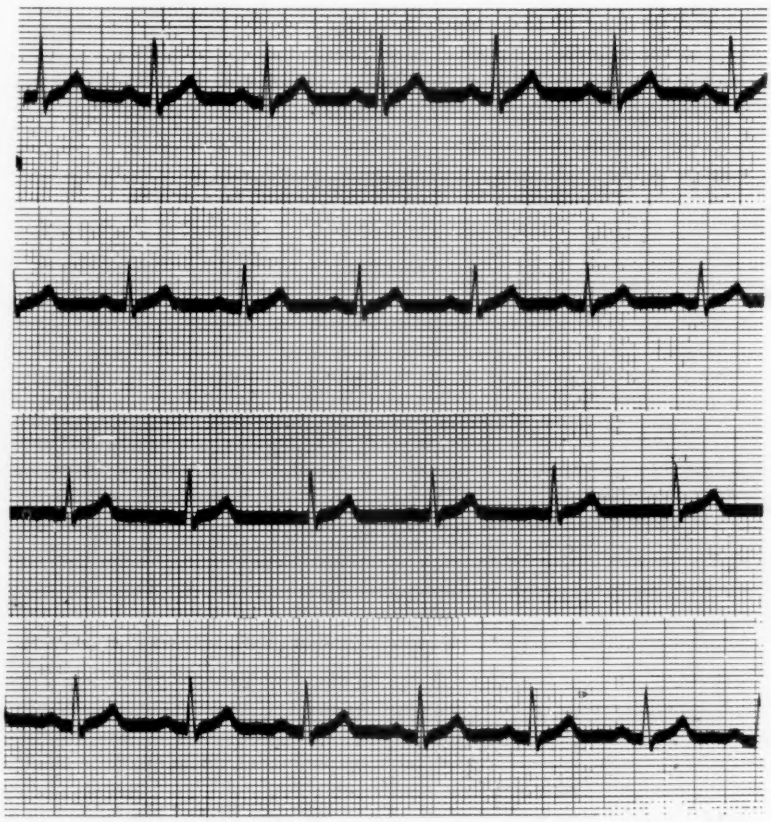

CHART 14.—Electrocardiographic Report: Series of lead 2 after taking potassium.
Sec. 1—sinus rhythm, ventricular rate 80 P–R = 0.19
Sec. 2—sinus rhythm, ventricular rate 78 P–R = 0.17
Sec. 3—sinus rhythm, ventricular rate 76 P–R = 0.15
Sec. 4—sinus rhythm, ventricular rate 80 P–R = 0.18
Section 1 is essentially identical with the control. There is not, however, the variation in the P–R as noted in the control. The form of the complexes is similar.
Section 2. The voltage throughout is distinctly lower and the conduction time is less than before, being 0.17 throughout.
Section 3. The low voltage persists, the P-waves now being of exceedingly low amplitude and the conduction time is further reduced to 0.15.
Section 4. This resembles very closely the first section in that the voltage is higher than in the second and third sections. The conduction time is greater.

lation potassium ions obtained by electrolytic dissociation, and found that like potassium salts, they produce a decrease in the number of contractions, a gradual diminution in the amplitude of the beat, and finally cessation of the heart action, electrocardiograms taken resembled those of muscular fatigue.

A relationship of hyperpotassemia to some of the peculiarities of heart action is suggested by two sets of experimental data and two human cases. As part of a study of human potassium tolerance[138] one of us (J. S.) took 20 mg. of potassium per pound of body weight. Electrocardiograms taken at intervals revealed that with an increase of 50 per cent in the capillary plasma potassium, there occurred a slowing of the rate, a decrease in the p.r. interval and a decrease in the amplitude of the complexes; all of which disappeared within two hours, at which time the plasma potassium had returned to normal.

A cat with a complete intestinal fistula showed, in addition to the above changes, T wave changes in leads two and three.[108] Cats dying of potassium poisoning gave the following electrocardiographic changes: Flattening and inversion of T waves in leads two and three; and intraventricular block and ventricular fibrillation.[15]

Case Report.—Case 2: A male, age 60, was admitted September 24, 1936, with the complaint of severe epigastric pain of eight hours' duration. The past history was important as he had had a partial thyroidectomy for cardiac insufficiency due to hyperthyroidism in May, 1935. The patient was referred to the Medical Service with a tentative diagnosis of coronary thrombosis because his electrocardiogram was suggestive of severe heart muscle damage. The exacerbations of the patient's pain, blood pressure, which remained constant, and good heart sounds were not consistent with coronary occlusion. Difference of opinion delayed operation for two days. An obstruction due to a band was found. The electrocardiograms showed improvement after treatment. The plasma potassium was 29 mg. per cent before, and 17 mg. per cent after operation and therapy.

Dr. Levy recalled another patient whose unusual history, absence of typical physical findings and electrocardiograms suggestive of severe heart muscle damage was watched for six days. Necropsy revealed several feet of gangrenous intestine, but no heart disease.

THE ACTION OF SALT.—In four conditions associated with dehydration, salt solutions have proved beneficial: *i.e.,* Asiatic cholera, fistulae of the gastro-intestinal tract, adrenal insufficiency and acute intestinal obstruction.

(1) *Cholera.*—Although intravenous saline was first used by Latta,[60] during the 1831–1832 Edinburgh epidemic,[61] the mortality for this disease was not appreciably decreased until Rogers[99, 100] introduced his treatment. The rediscovery of a low plasma bicarbonate by Sellards[109, 110] led to sodium bicarbonate therapy, which resulted in fewer cases of terminal uremia.

(2) *Salt Treatment in Intestinal Fistulae.*—Pawlow,[96] prolonged the lives of dogs with pancreatic fistulae by feeding sodium bicarbonate. The administration of sodium chloride and sodium bicarbonate has yielded similar results in other types of fistulae of the gastro-intestinal tract.[14, 26, 30, 32, 46, 86, 125]

(3) *Salt Treatment in Adrenal Insufficiency.*—Soddu's[112] observation, in 1898, that adrenalectomized animals given salt lived longer, was neglected until recent confirmation.[1, 5, 18, 43, 70, 102, 113, 134] Lowered alkaline reserve and the benefits of sodium bicarbonate and other sodium salts have been emphasized in this condition. In the adrenalectomized animals, the giving of sodium bicarbonate in amounts proportional to the lowered CO_2 was suggested by Zwemer.[140]

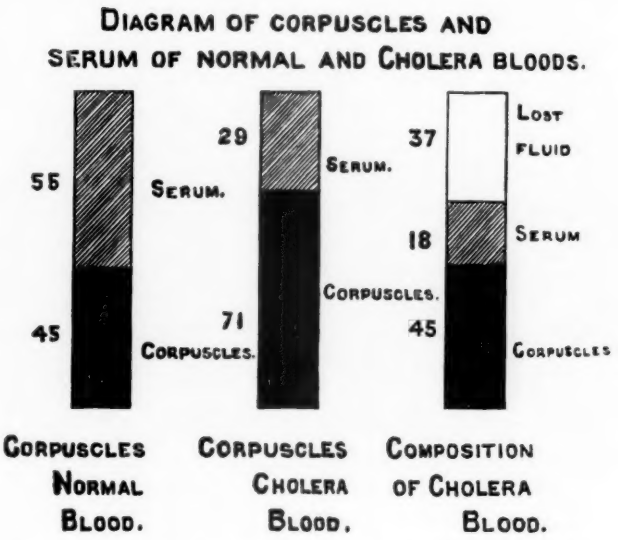

FIG. 1.—Hematocrit readings (cell volume) of normal and abnormal blood (Rogers[100]).

TABLE III

MORTALITY IN CHOLERA

Date	Type of Saline	Cases	Deaths	Mortality Per Cent
1831 (Latta and Mackintosh[61])	Saline intravenous	166		84
1893 (Wall[61])	Hypotonic subcutaneously	193		70
	Calcutta Medical College Hospital Series			
1895–1905	Rectal and subcutaneous hypotonic saline	1,243	783	59
1906	Normal saline intravenous	112	57	51
1907	Rectal and subcutaneous saline	158	94	59.5
1908–1909	Roger's hypertonic saline intravenous	294	96	32.6
1910–1914	Roger's hypertonic saline intravenous and permanganate per os	858	222	26
1915–1919	Roger's hypertonic and Roger's alkaline saline intravenous and permanganate per os	1,429	298	20.8

Formula for Roger's saline solution:

Sodium chloride	Gr. 120	(8.0 Gm.)
Potassium chloride	Gr. 6	(0.4 Gm.)
Calcium chloride	Gr. 4	(0.25 Gm.)
Distilled water	one pint	(568 cc.)

This prescription, therefore, contains 15.2 Gm. per liter, constituting a 1.52 per cent solution.

(4) *Salt Treatment in Intestinal Obstruction.*—Hartwell and Hoguet[48] showed the survival period in the obstructed dog was doubled by subcutaneous salt solution injections. Similar to Rogers'[99, 100] treatment of cholera, Haden and Orr[40] have advocated hypertonic saline in bowel occlusion. In the extremely toxic patient, Orr has urged a 2 per cent salt solution by hypodermoclysis, and a 3 to 5 per cent solution intravenously, the initial dose being 1 Gm. of NaCl per Kg. of body weight, in order to restore the blood chlorides.

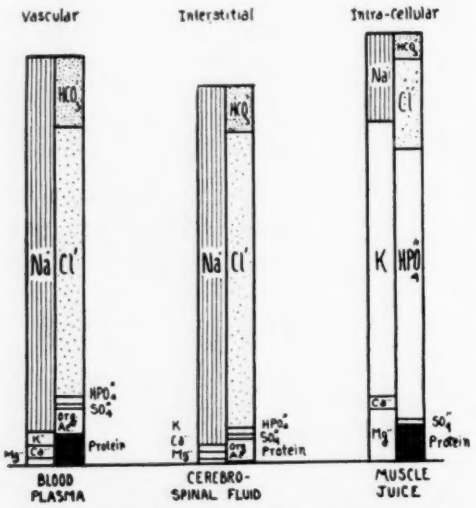

FIG. 2.—Acid-base composition of body fluids. This diagram is constructed from average values for individual factors expressed in terms of acid-base equivalence: *i.e.*, as cubic centimeters of tenth normal solutions per 100 cc. of fluid. Base factors are superimposed in left hand and acid factors in right hand of each column. They represent, as is actually the case, a structure composed not of salt but of individually sustained concentrations of ions. Exact acid-base equivalence indicated by equal height of two parts of each column is obtained by adjustability of bicarbonate ion concentration (HCO_3) to any change elsewhere in structure. (From McIver, M. A.: Acute Intestinal Obstruction, New York, Paul B. Hoeber, Inc., 1934.)

Hypertonic salt solutions shorten the survival in experimental adrenal insufficiency.[76] It appears from our experience that these strong solutions should *not be used alone in severe dehydration* because the resultant blood dilution is accomplished by ingress of cell water.

The similarity of the blood changes in the above four conditions is striking, and the values reported in the literature for three of them are given. In each, the beneficial action of sodium solutions has been attributed to correction of the altered biochemical changes of the blood, maintenance of blood volume, or the washing out of a hypothetical toxin.[100, 102, 105]

Since an increased blood potassium is found in certain phases of Asiatic cholera,[3, 104] adrenal insufficiency, intestinal fistulae, and acute intestinal obstruction, the success of saline therapy[2, 11, 51, 68, 120] might be attributed in part to its effect on potassium metabolism.

TABLE IV

SIMILARITY OF CERTAIN CONSTITUENTS OF THE BLOOD IN CHOLERA, ADRENAL INSUFFICIENCY AND ACUTE INTESTINAL OBSTRUCTION

Physical Characteristics	Asiatic Cholera	Adrenal Insufficiency	Acute Intestinal Obstruction
Red blood cells	Increased [71, 100]	Increased [36, 101, 114]	Increased [38, 81, 121]
Hemoglobin	Increased [71, 100]	Increased [44, 101]	Increased [4, 10, 64]
White blood cells	Increased [71, 100]	Increased with terminal fall [135]	Increased [121]
Specific gravity of blood	Increased [92, 100, 129]	Increased [101, 114]	Increased [107]
Hematocrit	Increased [92, 100]	Increased [7, 44, 114]	Increased [4, 38, 81]
Total solids	Increased [3, 104, 129]	Increased [23, 36, 47, 101]	Increased [55]
Anions			
Cl	Decreased [3, 93, 94, 99, 104]	Decreased [5, 7, 70, 101, 137]	Decreased [10, 31, 34, 39, 50, 72]
HCO_3	Decreased [67, 94, 110]	Decreased [70, 116, 118, 132]	Increased [31, 34, 39, 72, 80]; Decreased [81]
HPO_4	Increased [66, 71]	Increased [47, 69, 116]	Increased [4]
SO_4	.....	Increased [69]	Increased [4]
Proteins	Increased [66]	Increased [49, 114, 117]	Increased [4, 31, 38, 81]
Total acid	Decreased [66]	Decreased [118]	Decreased [4, 31, 34]
Cations			
Sodium	Decreased [3, 104]	Decreased [7, 70, 76, 137]	Decreased [4, 31, 34, 50]
Potassium	Increased [3, 104]	Increased [1, 7, 42, 49, 69, 75, 137]	Increased [19, 107]
Calcium	Increased [71]	Increased [7, 47]	Increased [50]
Magnesium	Increased [104]	Increased [7, 137]	Increased [83]
Total base	Decreased [66]	Decreased [7, 45, 69, 137]	Decreased [4, 31, 34]
Nonprotein Nitrogen	Increased [21]	Increased [5, 77, 101]	Increased [17, 24, 38, 119]
Urea	Increased [93, 94]	Increased [5, 97, 101, 103]	Increased [24, 38, 83, 119]
Uric acid	Increased [71]	Increased [47, 103]	Increased [10, 34]
Creatinine	Increased [71]	Increased [42, 47]	Increased [10, 34]
Blood Sugar	Increased [71]	Decreased [8, 114, 131, 136]	Increased [13, 24]
Hydrogen Ion Concentration	Increased [66, 67]	Increased [49, 118, 132]	Increased [50]

Volume 107
Number 2

SUMMARY

(1) Two thousand, one hundred fifty cases of acute intestinal obstruction, objectively analyzed, are reported with an evaluation of various surgical procedures used in relation to the patient's condition.

(2) Twenty-five additional cases are given in detail with determinations of plasma and blood density; hematocrit; plasma proteins; plasma, whole blood and cell potassium together with other constituents of the blood before and after therapy.

(3) The potassium contents of gangrenous loops, enterostomy drainage, gastric secretion, peritoneal and spinal fluids are given of several.

(4) Disturbances in blood potassium resulting from derangements in body fluids explain some of the symptoms found and the procedures used in acute intestinal obstruction.

(5) Hyperpotassemia is not peculiar to intestinal obstruction, but may be expected in all conditions associated with rapid, or excessive, entry of potassium into the blood stream together with dysfunction of the numerous regulatory mechanisms.

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SHORT-INTERVAL STAGE OPERATIONS FOR SEVERE HYPERTHYROIDISM

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NOTWITHSTANDING the continued improvements that from time to time have been devised in pre- and postoperative care, multiple stage operations still offer the best solution for the conduct of safe, yet adequate, surgical relief of the extremely toxic goiter patient. Their value has been repeatedly cited and amply demonstrated by various authors, but the intrinsic problems and alternatives of the operative procedures themselves have not always received proportionate attention. It is with some of these latter problems that this report is concerned.

Stage operations for hyperthyroidism, if one may judge from articles on the subject in periodicals and in text-books, are nearly always performed by one of two classical methods. The first method[1, 2, 3, 4, 7, 14, 17] consists of the exposure of the superior thyroid poles through separate, short incisions, permitting ligation of the polar arteries or, at least, their main branches. These polar ligations can be effected rapidly, almost bloodlessly, and if necessary without bringing the patient to the operating room. A subsequent subtotal thyroidectomy can then be performed after whatever interval the patient's improvement permits. In the days before our present knowledge of the efficacy of iodine as a preoperative measure,[22] such preliminary polar ligations were the only safe way to deal surgically with an extremely toxic goiter. In the light of present knowledge about preoperative treatment, more than ligations can often be accomplished safely at the first stage. Furthermore, there is the unsightliness of the additional two small scars to consider. The other classical method[8, 13, 15, 16, 18, 19, 21] is that of performing a subtotal hemithyroidectomy as a first stage, discharging the patient on a strict convalescent regimen for a period of usually not less than six weeks, then rehospitalization for preparation and subtotal removal of the other thyroid lobe. In the case of some very sick patients a series of operations may be necessary, commencing with ligations and followed by lobectomies. Under ideal conditions, and with patients who both can and will cooperate during the interval between operations, this second type of delayed operation is probably the method of choice, being safe in both stages, free from the risk of infection attending the early reopening of a wound, and on completion productive of as satisfactory an ultimate result as a single stage operation on a less toxic patient. Certain local factors, however, led us to seek, long ago, an alternate way of handling those goiter patients in whom some type of stage operation was obviously the only safe procedure. Such a method, its development, and its results in our hands, in 161 consecutive cases over a period of the past 13 years, are herewith described.

The factors referred to above which complicated our delayed stage operations were largely social and economic. The great majority of our patients, goiter or otherwise, were in the self-supporting, but low wage earning, stratum of factory workers and their wives; many of them had had only an elementary education, and many were of alien birth, unable or imperfectly able to speak and understand English. The number of women in this group was just double that of the men, a preponderance much less than that reported by various authors.[24] Some of these patients thought they were so much improved by a single lobectomy that they would not return for the second operation. Others waited long beyond the requested interval and returned for the second operation with their original degree of hyperthyroidism fully recurrent. Others found the economic strain made invalidism or even strict rest between operations difficult or impossible, with the result that their condition before the second operation was sometimes more precarious than it had been previous to the first. These factors combined to make delayed stage operations an unsatisfactory procedure in our hands.

Forced to make some compromise, and wishing if possible to use only a single period of hospitalization by shortening the interval between stage thyroidectomies, we first tried to consider the theoretic possibilities and then put them to clinical test. We knew that with the use of fine silk suture material, strictest asepsis, and gentle technic, wounds, even those of operations on the central nervous system, could be reopened without ensuing infection, after the lapse of but a few days' time.[5, 6, 11, 12] It furthermore seemed probable that the optimum time for reopening a clean wound would lie in the period after the edema and other reactions to operative trauma had largely subsided and before vascularization and cicatrization had proceeded to a point where they would complicate a second operation—i.e., somewhere between the fifth and twelfth postoperative days. The crux of our problems was whether or not sufficient clinical improvement for a safe reoperation would dependably occur within the above mentioned interval, when early reopening of a thyroid wound would least likely result in infection or poor healing. After trial and observation of time intervals varying from one day to two weeks, we became convinced that the optimum period for "short-interval" stage thyroidectomies is from seven to ten days between operations. After bilateral ligation of the superior polar arteries, and more strikingly after subtotal hemithyroidectomy, it is surprising how rapidly clinical improvement occurs after the first critical 36 to 48 hours have passed.

Table I shows certain facts about 189 consecutive stage thyroidectomies performed during the years 1924 through 1936. These represent 12 per cent of the 1435 thyroidectomies performed during the same period. Before 1928, when the relative incidence of goiter patients began to decrease,[20] 19 per cent of our thyroidectomies were performed in stages, but since 1928 only 8 per cent. Section (A) indicates our experience with delayed two-stage operations.

TABLE I

TYPES OF TWO STAGE THYROIDECTOMIES

(189 Consecutive Cases, 1924–1936)

	Total Cases	Operative Mortality	Wound Infection
(A) Delayed (4–6 wk. interval)	14	21%	7.0%
(B) Reoperation within 48 hrs.			
1—Wound closed after 24–36 hrs.	13	0%	7.5%
2—Double lobectomy 48 hrs. after ligation	1	100%	0 %
(C) Reoperation after 6–12 days			
1—Double lobectomy completed after bilateral ligation	94	0%	23.0%
2—Separate lobectomies completed	48	0%	10.5%
3—Other combinations of procedure	19	49% *	15.0%

* This mortality figure is accounted for by the fact that Group 3 includes all patients who survived operations of more than two stages; also all patients who failed to survive the operations planned for them.

The high mortality (21 per cent) in our small series of 14 operations of this type was partly responsible for our efforts to shorten the interval, even though we did not feel that the mortality was due to any fault in the underlying principles of delayed stages themselves. We laid it rather to our inability to get the patients to cooperate in applying the principles correctly. Sections (B) and (C) deal with the patients upon whom operation was not delayed beyond 12 days. In 13 toxic patients upon whom the complete operation was performed, the wound was packed open as a time saving safety measure, and sutured on the first or second subsequent day. No infection occurred after these operations. We rejected this type of stage operation, however, because we did not think it advisable to employ it on extremely toxic patients, and felt that a reduction of the amount of surgery on the gland itself was a more important safety factor than a mere reduction of the time of operation by the few minutes involved in wound closure. Of the 161 "short-interval" stage operations, 94, or 58 per cent, first had a bilateral superior polar ligation through a collar incision. After an interval varying from six to 12 days, the original wound was reopened and a subtotal bilateral excision was performed as the second and final stage. Forty-eight patients, or 30 per cent, had first one lobe and later the other lobe subtotally resected after a similar interval and likewise through the same collar incision. Among the 20 remaining cases various combinations were tried, usually three stage operations beginning with a bilateral ligation, followed by one and later a second subtotal lobectomy, all performed through the same collar incision. The basic technic of all operations in this series was that originally developed by Kocher in Switzerland and Halsted in this country and described by the latter in his "Operative Story of Goiter."[9] In various details, suggestions in a more recent illustrated descriptive article by Halsted's pupils, Reid and

Andrus,[23] were followed. Silk was used in every case. After making the usual collar incision and freeing the sternohyoid and sternothyroid muscles of one side along their mesial borders, the upper pole was first carefully freed from its blood supply and mobilized, thus aiding a safe yet thorough exposure of the middle portion and lower pole. This done, excision of the entire upper pole and all but a small posterolateral slice of the remainder of the lobe was proceeded with, working from the periphery toward the trachea and isthmus. Where two separate lobectomies were performed, sufficient exposure was usually obtained at the second operation by retracting the sternohyoid and sternothyroid muscles laterally. Where preliminary ligations were effected, the resulting edema and induration of these ribbon muscles at the second operation hindered exposure and often necessitated transverse division between clamps.

TABLE II

DURATION OF HOSPITALIZATION

Average number of days in hospital before operation	12.9
Average number of days in hospital between stages	8.8
Average number of days in hospital after second stage	10.5
Average total days in hospital	32.2

Table II deals with the period of hospitalization of these "short-interval" cases. At the present time, and for some years past, the usual hospital stay of a moderately toxic goiter patient is seven days before operation and eight to ten days after operation. The table shows the average number of days elapsing before the first stage, between stages, and after the second stage. The extra number of days before the first operation is reasonably accounted for by the severe degree of toxicity of these cases. The number of days after the final operation, however, is only at the upper limit of what we usually find adequate for less toxic patients with complete operations. The total number of days in the hospital averaged 32.2. This suggests that a "short-interval" procedure for stage thyroidectomies will save a patient on an average a week's hospital stay in addition to the four weeks of invalidism and economic dependence necessary between discharge after the first of two delayed-stage operations and reentry to prepare for the second operation. It furthermore eliminates poor cooperation on the patient's part and any tendency not to return for the second operation. Our care of patients between stages has consisted simply in replacing them on their original preoperative regimen of rest, high fluid and carbohydrate intake, Lugol's solution, and mild sedation as soon as their immediate reaction to the first operation permits. This is usually possible by the third day. In selecting the day for the second operation we have been guided mainly by the patient's temperature, pulse, condition of wound, clinical appearance and subjective symptoms of improvement. A significant drop in the metabolic rate early after the first operation has occurred so seldom that had we depended on this sign alone we would not have operated a second time within so short a period. A few patients have been told in

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advance that stage operations were to be performed, but most of them have not been told until the morning of the second operation.

TABLE III

EVIDENCE OF SEVERE HYPERTHYROIDISM

Initial preop. B. M. R. +70% or higher	29% of series
Initial preop. B. M. R. +50% or higher	74% of series
Initial B. M. R. below +50% but with associated toxic myocarditis	45% of series
Highest postop. rectal temp. above 103° F.	40% of series
Highest postop. rectal temp. above 102° F.	74% of series
Average preop. pulse pressure	70 Mm. Hg.

Table III summarizes some clinical observations, and is presented as showing the severe toxicity or otherwise complicated nature of the series of cases under consideration.

TABLE IV

OPERATIVE MORTALITY AMONG 161 "SHORT-INTERVAL" OPERATIONS

(A) Gross mortality		12 deaths	7.5% of group
(B) After 94 operations planned for initial ligations		11 deaths	11.5% of subgroup
(a) After ligation only		in 7 instances	
(b) After ligation + single lobectomy		in 1 instance	
(c) After ligation + bilateral lobectomy		in 2 instances	
(d) After ligation and 2 separate lobectomies		in 1 instance	
(C) After 48 operations planned as 2 separate lobectomies (This death occurred after the first lobectomy)		1 death	2.0% of subgroup
(D) Assigned causes of death—whole group			
(a) Myocardial failure		10 instances	
(b) Acute hyperthyroidism		9 instances	
(c) Pneumonia		2 instances	
(E) Deaths by age decades—whole group			
10–19 yrs. group	5 patients	0 deaths	0.0% of group
20–29 yrs. group	24 patients	0 deaths	0.0% of group
30–39 yrs. group	51 patients	2 deaths	3.9% of group
40–49 yrs. group	35 patients	0 deaths	0.0% of group
50–59 yrs. group	32 patients	5 deaths	15.5% of group
60–69 yrs. group	14 patients	5 deaths	36.0% of group
Total	161 patients	12 deaths	7.5% of group

Table IV deals with the operative mortality of this series. In the "short-interval" group of operations 12 patients should be considered operative deaths. These deaths are analyzed in Table IV. Not only were all of these patients severely toxic, but nine of the 12 were advanced thyrocardiacs, and two subject, in addition, to attacks of angina pectoris. For eight months of the current year (1937) we have had at our disposal a newly developed type of oxygen tent for immediate postoperative use.[10] The tent is operated by the gradual vaporization of liquid oxygen. Its use has given such satisfactory aid in reducing or abolishing the severe reaction of toxic patients to operation that we have hopes of lowering the mortality rate in our future stage operations on patients who are very poor risks.

TABLE V

POSTOPERATIVE COMPLICATIONS OTHER THAN WOUND INFECTION

(*Entire Series of 189 Stage Operations*)

Hypothyroidism	24 — 12.5%	Shock	2 — 1.1 %
Recurrence	22 — 11.5%	Pneumonia	2 — 1.1 %
Vocal cord paresis	18 — 9.5%	Hematoma	2 — 1.1 %
Death	15 — 8.0%	Acute hemorrhage	1 — 0.55%
Acute hyperthyroidism	14 — 7.5%	Tetany	1 — 0.55%
Myocardial failure	13 — 7.0%		

Table V shows the postoperative complications other than infection encountered in this series in the descending order of their frequency. The vocal cord weakness or paralyses were all unilateral. They occurred in 12.5 per cent of the separate lobectomies and in 10.5 per cent of the stage operations where only ligations were performed first. In the matter of recurrent or persistent hyperthyroidism, however, the difference in results between the two types of short-interval operation is more significant. Eighteen of the 21 recurrences were in operations other than two separate lobectomies, the percentages being 17 and 6 respectively. Some degree of hypothyroidism occurred postoperatively in 24 patients. These patients represent 13.5 per cent of the entire series. Subtracting the recurrent and hypothyroid patients leaves 74.5 per cent with an entirely satisfactory ultimate result.

TABLE VI

WOUND INFECTION

(*Entire Series of 189 Stage Operations*)

Total	32 — 17.0%
Brief	23 — 12.8%
Protracted	5 — 2.6%
Severe	3 — 1.6%
Contributory to death	0 — 0 %
Permanently disfiguring	0 — 0 %
In prelim. ligation operations	22 — 23.0%
In 2 lobectomy operations	5 — 10.5%

Of all complications, however, wound infection has been the most frequent and given us the most serious concern. We believe, though, that we have learned some points about its control. Were it not for the facts shown in Table VI, which lists every wound in which there was the slightest deviation from clean healing, and were it not for our belief that every infection can be laid to some observed or undetected flaw in technic, we would long ago have abandoned trying to shorten the interval between stages. As 82.5 per cent of wounds healed per primam, as three-quarters of the infections were of a transient and trivial nature, and as no wound infections contributed to operative mortality or caused permanent disfigurement, we feel this disagreeable complication is one that can be progressively reduced by ever increasing care in technic. Infection occurred only half as frequently in separate single lobectomies as in all other types of operation, 10.5 per cent as against 21.5 per cent.

DISCUSSION

In addition to the use of fine silk and careful hemostasis throughout both operations, it is of great importance and help to avoid bleeding wherever possible, especially during dissection of the skin flaps by care in keeping in the proper tissue planes and by avoiding all unnecessary tearing or section of vessels. The quantity of ligature material left in the subcutaneous tissues is thus materially lessened. If the patient's condition permits, unilateral lobectomy is the first stage operation of choice. It gives proportionately more symptomatic relief and improvement within the subsequent interval of seven to ten days and permits one to leave the remaining lobe with its fascial and muscular coverings unmolested until the second stage is undertaken. We consider this noninterference with the unoperated lobe very important. At the first stage, furthermore, the entire isthmus and pyramidal lobe, if present, should also be thoroughly removed—even at the expense of dealing first with the smaller of two diffusely hyperplastic lobes. At the second operation the region of the previously operated thyroid fossa should be left strictly untouched, sponged, or explored. At the conclusion of the first stage it is preferable to omit subcutaneous suture of the skin flaps, to use skin clips for the skin edges rather than through-and-through sutures, and to avoid draining the wound. Before proceeding with the second operation, the slightest imperfection in wound healing should be allowed to clear up completely. The incision line and neck should receive very thorough but gentle preoperative cleansing. The wound should be reopened gently and slowly, to cause as little subcutaneous bleeding as possible, and to allow any area in the wound suspicious of infection to be detected before the wound is widely opened and the temptation not to postpone the operation great. During the second operation the already operated side should be left as strictly untouched as was the other lobe at the first operation. At the end of the second operation the wound should again be reclosed without subcutaneous skin sutures and again preferably with skin clips. Contrary to our original fears the final scars of these two stage operations have surprised us with their excellence. The matter of drainage after the second operation must be left to the operator's judgment in the individual case. No drains should be left in situ more than 24 hours. With the above mentioned precautions in technic, a short-interval two stage thyroidectomy is submitted as an operation that can safely and satisfactorily be employed as an alternative to delayed stage operations for patients with severely toxic goiter.

SUMMARY

(1) Certain goiter patients for reasons usually involving their financial or educational status do not cooperate satisfactorily in the conduct of two stage thyroidectomies where the operations are spaced four to six weeks apart.

(2) The feasibility is discussed of conducting the entire surgical treatment of such goiter patients within a single period of hospitalization of a month or less through shortening the interval between operations to a week or ten days.

(3) A consecutive series of 161 such "short-interval" two stage thyroidectomies is presented, the results analyzed by tables and discussed.

(4) Technical points of two stage operations are described, chiefly those tending to minimize the risk of wound infection. These include the use of silk; great care to avoid incurring unnecessary bleeding as well as meticulous hemostasis; avoidance of subcutaneous sutures in closure of the wound.

The author wishes to express his indebtedness to Dr. Roy D. McClure, Surgeon-in-Chief, Henry Ford Hospital, Detroit, Mich., for the privilege of collaborating in the study and surgical procedures of this series of patients and for permission to review the cases considered herein for the purposes of this report. Appreciation is also made to Dr. Edward Canipelli for his help in the preparation of the tables.

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FACTORS INFLUENCING PROGNOSIS IN CARCINOMA OF THE BREAST *

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THERE are many excellent articles in the literature concerning the prognosis of carcinoma of the breast. Many surgeons have studied this from the clinical viewpoint and many pathologists have attempted to estimate the prognosis upon an histologic study of the tumor. There have been very few reports correlating clinical and pathologic study.

A clinical classification is presented. The histologic classification of Haagensen is used. It is hoped that these classifications may be used in future studies at larger hospitals and clinics. In this way we may learn the prognosis of cases of certain extent and microscopic type. Thus we may determine, for example, that a carcinoma of the breast with only pectoral gland metastasis of a comedo carcinoma type results in a certain percentage of cures. This is much more satisfactory than stating that one surgeon cures 35 per cent of his cases while another cures only 25 per cent. The former surgeon probably sees earlier stages of the disease due to caring for a more intelligent class of people.

A standard method of study of these cases, giving both clinical and microscopic types and stages of the disease, should have approximately the same results if treated similarly. After finding these results, the value of various forms of treatment can be better determined.

This study is based upon a careful review of 60 cases of carcinoma of the breast cared for in private practice at Immanuel Hospital by my father, B. B. Davis, and myself, also upon 23 cases at the University of Nebraska Hospital treated by various surgeons. In both groups the study begins at the earliest date that microscopic sections of the tumors were kept for record. This began at Immanuel Hospital in 1922, and at the University of Nebraska Hospital in 1927. No cases are included that were admitted for treatment later than 1932, so that there are at least four years intervening since they were first seen. I have personally reviewed the histories, studied the microscopic sections and obtained reports of their present condition. No effort is being made to prove any certain fact but the study is made merely to see what the results have been. It is realized that this series of cases is far too small to justify one in drawing very definite conclusions from them.

In the operable cases the treatment was radical mastectomy by one of the standard methods, removing the breast and dissecting out the axilla, with re-

* Read before the Western Surgical Association, Kansas City, Mo., December 12, 1936. Submitted for publication April 12, 1937.

moval of the lymph nodes there. Exception was made in only three cases. In these a simple mastectomy without axillary dissection was performed. In addition to radical mastectomy, postoperative roentgen-therapy was carried out in ten cases and preoperative radiation in three. In recent years I have used preoperative radiation much more frequently. Recurrence has usually been treated by irradiation and occasionally by local excision.

TABLE I

BREAST CASES

Hospital	Cases Studied	Benign Microscopically	Carcinoma				
			Primary Operable			Recurrent	
			Total	No.	Per Cent	No.	Per Cent
Immanuel 1922–1932 (private cases)....	60	6	51	51	94	3	6
University 1927–1932.....	23	2	19	15	71	2	9
Totals.....	83	8	70	66	88	5	7

TABLE II

PRIMARY BREAST CARCINOMA
OPERABLE CASES

Results—November, 1936

Hospital	Total	Operated	Results Known	Well		Dead							
				No.	Per Cent	Carcinoma Deaths		Operative Deaths		Other Causes		Total	
						No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent
Immanuel..	51	51	41	12	29	25	61	2	5	2	5	29	70
University.	15	14	13	4	31	8	61	1	7	0	0	9	69
Total....	66	65	54	16	30	33	61	3	6	2	3	38	70

In the early years of the study, six cases in the Immanuel Hospital series were diagnosed on their records as carcinoma which, on study of the sections, I believe were benign. Four of these I know to be well but have not been able to follow-up the other two. The diagnosis in 54 cases was carcinoma, checked either by microscopic section or by death from metastases. Fifty-one of these cases were operated upon. I know the results in 41, 12 of which are well now, which is a period of four to 14 years after operation. This is 29

per cent of the traced cases. The percentage of five-year so-called cures is actually higher as several of the cases reported as dead were well for longer than five years. Besides this, two cases had operative deaths and two died of causes unrelated to the carcinoma.

Of 13 traced University Hospital cases, four, or 31 per cent, are now well. In the combined series I know the results in 54 out of 65 operated cases. Of the 54, 16 cases, or 31 per cent, are well while 33 cases, or 61 per cent, are dead as a direct result of the carcinoma. The other eight deaths were not due to carcinoma itself.

The average age of the patients upon admission was 53½ years. The youngest proved case was 28. Most of the cases previously diagnosed carcinoma, but which I consider benign, were of the younger age groups. The oldest case was 80.

TABLE III

AGE INCIDENCE

Age	Immanuel				University				Total			
	No.	Unknown	Result		No.	Unknown	Result		No.	Unknown	Result	
			Well	Dead			Well	Dead			Well	Dead
20–29..	0	0	0	0	1	0	0	1	1	0	0	1
30–39..	5	0	1	4	1	0	0	1	6	0	1	5
40–49..	12	4	5	3	9	2	1	6	21	6	6	9
50–59..	23	2	5	16	5	0	1	4	28	2	6	20
60–69..	9	3	1	5	3	0	1	2	12	3	2	7
70–79..	3	1	0	2	2	0	1	1	5	1	1	3
80.....	1	0	0	1	0	0	0	0	1	0	0	1
Age not stated.	1	1	0	0	0	0	0	0	1	1	0	0
Totals..	54	11	12	31	21	2	4	15	75	13	16	46

It is seen that 61 cases, or 81 per cent, were between the ages of 40 and 69. The series is inconclusive in proving any age group more malignant than the others. A much larger series of cases is needed.

Chart 1 indicates that the private cases came for treatment somewhat earlier than the University Hospital cases. In the former, 16 were operated upon within a month of the time of the first symptom. In the University Hospital series only two presented themselves that early and one of those was admitted for trouble other than the carcinoma of the breast, which was discovered in the course of the routine physical examination. Thirty-six, or 67 per cent, of the private cases were seen within two months of the onset. During the same length of time only five, or 24 per cent, of the University Hospital cases were admitted. In another series of 60 cases at the University

Hospital which was reviewed two years ago it was found that 50 per cent had had symptoms for over one year before admission.

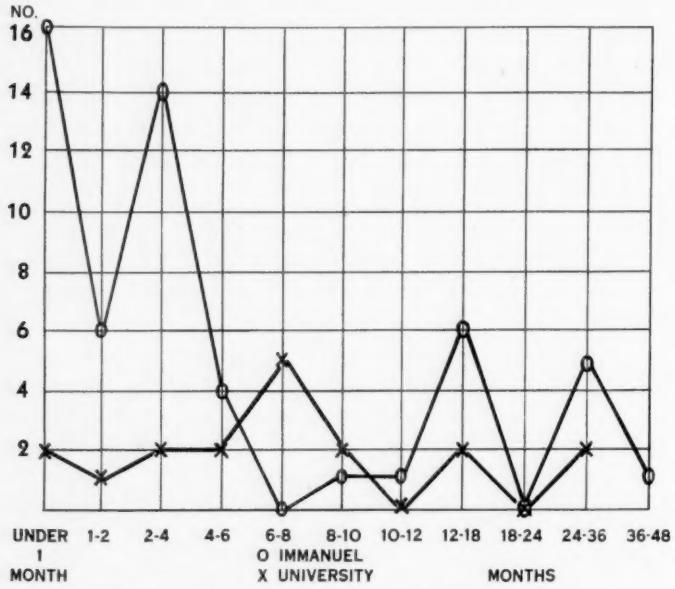

CHART 1.—Showing duration of tumor previous to admission.

Chart 2 shows that 75 per cent of the cases still well were operated upon within six months of the onset and 25 per cent between six and 12 months. There was not a single cure in cases of one year or over. This proves very

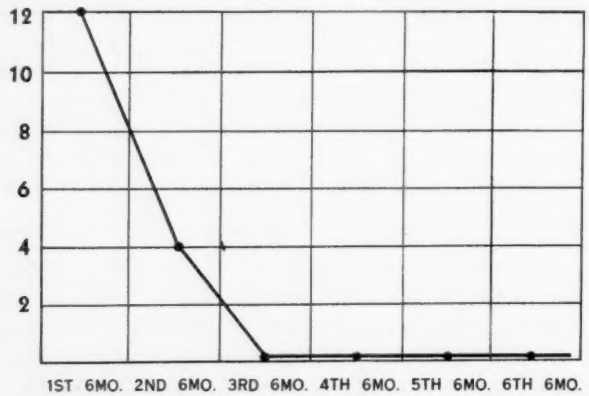

CHART 2.—Shows the precipitant decrease of favorable prognoses, predicated upon the duration of the disease previous to admission.

conclusively that early diagnosis and treatment are very essential in the cure of carcinoma of the breast. The question of the advisability of surgery for cases of long duration is raised.

Aside from the duration of disease, a knowledge of the extent of it is im-

portant in determining prognosis. For this purpose the following clinical classification is presented:

P*1—Early, nonadherent tumor without metastasis
P 2—Tumor adherent to skin or fascia without metastasis
P 3—Tumor with only pectoral node metastasis
P 4—Tumor with general axillary node metastasis
P 5—Tumor involving pectoral fascia with axillary node metastasis
P 6—Large bulky tumor
(a) Without axillary node metastasis
(b) With axillary node metastasis
P 7—Tumor with skin metastasis
P 8—Tumor with bone metastasis
P 9—Tumor with intrathoracic metastasis
P10—Tumor with several types of distant metastases
P11—Bilateral breast tumor
P12—Carcinoma during pregnancy or lactation
R 1—Local recurrence in scar
R 2—Metastasis to skin
R 3—Axillary involvement
R 4—Distant recurrence
(a) Bony
(b) Intrathoracic
(c) Cerebral
(d) Abdominal

*P = Primary. R = Recurrent.

Of the primary classes, the first six, and possibly the last two, may be operable. Class 7 may possibly be made operable by preoperative irradiation. Classes 8 to 10 inclusive are distinctly inoperable and palliation only can be considered.

TABLE IV

CLINICAL CLASSIFICATION OF BREAST CARCINOMA

	Immanuel	University	Total
P*1	24	1	24
P 2	1	5	6
P 3	9	2	11
P 4	10	4	14
P 5	0	0	0
P 6a	0	0	0
P 6b	5	2	7
P 7	0	1	1
P 8	0	1	1
P 9	0	0	0
P10	1	2	3
P11	0	0	0
P12	1	0	1
Not stated	0	1	1
Totals	51	19	70

* P = Primary

Most of the recurrent cases are inoperable, with the possible exception of those occurring in Class 1, *i.e.*, local recurrence. With adequate radical mastectomy this is rare.

As the private cases were seen sooner after the onset, the clinical class in general is lower than in the University Hospital cases. Forty-four cases, or 86 per cent, of the Immanuel Hospital cases were of one of the first four clinical classes, while only 12 cases, or 63 per cent, of the University Hospital cases were in these classes.

TABLE V

PERCENTAGE OF CURES DEPENDING UPON CLINICAL EXTENT

		Well		Dead		Unknown	
	Total	No.	Per Cent	No.	Per Cent	No.	Per Cent
P 1.....	25	10	40	10	40	5	20
P 2.....	6	3	50	3	50	0	0
P 3.....	11	2	18	6	55	3	27
P 4.....	14	0	0	13	93	1	7
P 5.....	0	0	0	0	0	0	0
P 6a.....	0	0	0	0	0	0	0
P 6b.....	7	1	14	4	57	2	29
P 7.....	1	0	0	1	100	0	0
P 8.....	1	0	0	1	100	0	0
P 9.....	0	0	0	0	0	0	0
P10.....	3	0	0	3	100	0	0
P11.....	1	0	0	1	100	0	0
P12	0	0	0	0	0	0	0
?.....	1	0	0	0	0	1	100
Totals.....	70	16	23	42	60	12	17

Table V shows that the cures decrease rapidly when gross metastases are found in the axilla.

While Types P1 and P2, which are the cases with no demonstrable axillary metastases, give at least 40 to 50 per cent of cures, even low axillary metastases result in only 18 per cent now reported as well. There is only one case now well in which the cancer had spread to the other axillary nodes. This raises the question of the advisability of very thorough dissection of the central and infraclavicular groups of axillary nodes lying along the course of the axillary vein. If the results are so poor, may it not be better to leave these high axillary nodes and so decrease the number of cases of postoperative swelling of the arm? A larger series of cases would be necessary to decide this question.

Histologically I am using the classification of Haagensen. It considers: (1) The manner of growth of cells; (2) cell morphology; and, (3) the reaction of the stroma. In detail it is as follows:

TABLE VI

HAAGENSEN'S HISTOLOGIC CLASSIFICATION

Manner of Growth of Cells
- (1) Papillary: Origin in a cyst formed in a duct
- (2) Comedo: Growth mainly within ducts
- (3) Plexiform: Growth in plexiform strands
- (4) Adenoid arrangement of cells

Cell Morphology
- (5) Size of cells
- (6) Size of nuclei
- (7) Variation in size and shape of nuclei
- (8) Hyperchromatism of nuclei
- (9) Number of mitoses
- (10) Secretory activity of cells
- (11) Clearness of cytoplasm

Reaction of Stroma
- (12) Fibrosis
- (13) Hyaline degeneration
- (14) Lymphocytic infiltration
- (15) Gelatinous degeneration
- (16) Invasion of lymphatics

Let us now consider the manner of growth of cells. The results in the cases under consideration are as follows:

		Well		Dead		Unknown	
	Total	No.	%	No.	%	No.	%
(1) Papillary	2	0	0	2	100	0	0
(2) Comedo	15	5	33	7	47	3	20
(3) Plexiform	37	9	24	22	60	6	16
(4) Adenoid	8	3	38	4	50	1	12
Totals	62	17	27	35	57	10	16

Two died of shock of operation. Two died of other disease.

Different parts of the same tumor may be of quite different histologic types. Even in a single microscopic section there may be several types very distinctly represented. In following Haagensen's classification with four types, depending upon manner of growth of cells, we found two distinct types in nine cases, three types in three, and all four types in one case. We classified these cases in the prevailing type from the sections studied. Therefore, histologic grading is definitely subject to error.

How does the growth of cells histologically affect each of these classes?

CLASS PI—EARLY NONADHERENT TUMOR WITHOUT METASTASES

	Total	Well	Dead	Unknown
Papillary	0	0	0	0
Comedo	10	4	3	3
Plexiform	9	3	5	1
Adenoid	3	2	0	1
Not stated	3	1	2	0
Totals	25	10	10	5
Per cent		40%	40%	20%

CLASS P2—TUMOR ADHERENT TO SKIN WITHOUT METASTASES

	Total	Well	Dead	Unknown
Papillary	0	0	0	0
Comedo	1	1	0	0
Plexiform	5	2	3*	0
Adenoid	0	0	0	0
Totals	6	3	3	0
Per cent		50%	50%	

* One was an operative death

CLASS P3—TUMOR WITH ONLY PECTORAL NODE METASTASES

	Total	Well	Dead	Unknown
Papillary	1	0	1*	0
Comedo	1	0	1	0
Plexiform	5	2	1	2
Adenoid	3	0	2†	1
Not stated	1	0	1	0
Totals	11	2	6	3
Per cent		18%	55%	27%

* Had local excision; 1 yr., 9 mos. later, radical mastectomy. Died 12 yrs. after first operation.

† One died of cerebral hemorrhage suddenly several years after operation.

CLASS P4—TUMOR WITH GENERAL AXILLARY NODE METASTASES

	Total	Well	Dead	Unknown
Papillary	0	0	0	0
Comedo	2	0	2	0
Plexiform	10	0	9*	1
Adenoid	2	0	2	0
Totals	14	0	13	1
Per cent			93%	7%

*(1) One died of shock four days after operation. (2) One died of apoplexy 1 yr. after operation. (3) Had tumor for 2 yrs. before operation and died 5⅓ yrs. after onset.

In Classes 5 and 6a there were no cases.

CLASS P6B—LARGE BULKY TUMOR WITH AXILLARY NODE METASTASES

	Total	Well	Dead	Unknown
Papillary	0	0	0	0
Comedo	0	0	0	0
Plexiform	6	1*	3	2
Adenoid	1	0	1†	0
Totals	7	1	4	2
Per cent		14%	57%	29%

* Age 51, tumor 1 yr. Very large ulcerating mass with bulky axillary metastases. Had considerable adenoid type also. Performed simple mastectomy only, postoperative roentgenotherapy. Still well 12 yrs. after onset.

† Died four days postoperative of shock.

CLASS P7—TUMOR WITH SKIN METASTASES

One case, 6 mos. duration, roentgenotherapy only. Died 9 mos. from onset. No microscopic section.

CLASS P8—TUMOR WITH BONE METASTASES

One case, 2 mos. duration, roentgenotherapy to spine. Died 4 mos. after onset. No microscopic section.

CLASS P10—TUMOR WITH SEVERAL TYPES OF DISTANT METASTASES

	Total	Well	Dead
Papillary	0	0	0
Comedo	0	0	0
Plexiform	1	0	1
Adenoid	0	0	0
No section	2	0	2
Totals	3	0	3
Per cent			100%

CLASS P11—BILATERAL BREAST TUMOR

Case, age 42. Second breast operation—radical mastectomy. Five years before had first radical mastectomy of other breast. Died 7 yrs. after onset.

An interesting fact in the above study is that, while both cases of a papillary carcinoma, which is usually considered not highly malignant, died, they each lived a considerable time. The case in private practice, age 50, had a tumor for two years before treatment, and it had invaded the pectoral lymph nodes. This case lived 12 years. The case at the University Hospital, age 55, also had a tumor for two years before treatment with invasion of all the axillary nodes. She was given preoperative roentgenotherapy followed by a radical mastectomy. She lived 5 1/3 years from the date of onset. In both of these cases the ultimate death may be attributed to the delay in institution of treatment. This series of cases, again, is too small from which to draw definite conclusions.

Using the above classification, Haagensen divided the cases histologically into three grades:

(I) When papillary or comedo, when adenoid arrangement of cells was marked, when gelatinous degeneration was present, or if lacking any of these preceding characteristics, when variation in the size and shape of the nuclei was slight and there were but few mitoses.

(II) All others.

(III) Highly malignant tumors. Absence of adenoid arrangement, marked variation in the size and shape of nuclei, and numerous mitotic figures. If any two of these three present—Grade 3.

What are the results in the various grades in each clinical class considered separately?

CLASS P1—EARLY NONADHERENT TUMOR WITHOUT METASTASES

	Total	Well	Dead	Unknown
Grade 1	11	7	1	3
Grade 2	6	1	3	2
Grade 3	5	1	4	0
Unknown	3	1	2	0
Totals	25	10	10	5
Per cent		40%	40%	20%

CLASS P2—TUMOR ADHERENT TO SKIN WITHOUT METASTASES

	Total	Well	Dead	Unknown
Grade 1	1	1	0	0
Grade 2	3	0	3*	0
Grade 3	2	2	0	0
Totals	6	3	3	0
Per cent		50%	50%	

* One was an operative death.

CLASS P3—TUMOR WITH ONLY PECTORAL NODE METASTASES

	Total	Well	Dead	Unknown
Grade 1	5	1	3*,†	1
Grade 2	4	1	1	2
Grade 3	1	0	1	0
Not stated	1	0	1	0
Totals	11	2	6	3
Per cent		18%	55%	27%

* Had local excision; 1 yr., 9 mos. later, radical mastectomy. Died 12 yrs. after first operation.

† One died of cerebral hemorrhage, suddenly, several years after operation.

CLASS P4—TUMOR WITH GENERAL AXILLARY NODE METASTASES

	Total	Well	Dead	Unknown
Grade 1	5	0	5*	0
Grade 2	3	0	3	0
Grade 3	6	0	5	1
Totals	14	0	13	1
Per cent		0%	93%	7%

* Tumor for 2 yrs. before operation, died 5⅓ yrs. after onset. One died of apoplexy 1 yr. after operation. One died of shock 4 days after operation.

CLASS P6B—LARGE BULKY TUMOR WITH AXILLARY NODE METASTASES

	Total	Well	Dead	Unknown
Grade 1	1	0	1*	0
Grade 2	1	0	1	0
Grade 3	5	1	2	2
Totals	7	1	4	2
Per cent		14%	57%	29%

* Died of shock 4 days postoperative.

The result of summarizing the statistics noted in the preceding tabulations, relative to the question of grading, is appended.

	Total		Well		Dead		Unknown	
	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent
Grade 1	23	100	9	39	10	44	4	17
Grade 2	17	100	2	12	11	65	4	23
Grade 3	19	100	4	21	12	63	3	16
Unknown	4	100	1	25	3	75	0	0

It is to be noted that we obtain distinctly better results in Grade 1 than in Grades 2 and 3. Unexpectedly, the results are a little better in Grade 3 than in Grade 2. This would probably not be true for a large series.

SUMMARY

(1) A method of study is presented to determine the prognosis in carcinoma of the breast. This considers both the clinical extent of the carcinoma and the histologic study.

(2) A new clinical classification depending upon the extent of the growth is discussed.

(3) The histologic classification of Haagensen is used.

(4) This study is based on 75 cases of proved carcinoma of the breast.

(5) The most important factors in determining prognosis are delay in institution of treatment and the extent of the disease.

(6) The histologic classification seems to be of less importance than the clinical study, but has a definite value.

(7) No attempt has been made to determine the value of various forms of treatment.

(8) It is realized that this series of cases is quite small. It is hoped that this method of study may be adopted at larger clinics so that a greater number of cases may be followed.

INTRATRACHEAL SUCTION IN THE MANAGEMENT OF POSTOPERATIVE PULMONARY COMPLICATIONS

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STASIS of secretions within the tracheobronchial tree is an important cause of postoperative pulmonary complications, notably atelectasis, aspiration "pneumonia," suppurative pneumonitis and pulmonary abscess. The constant maintenance of adequate intrabronchial drainage is essential in the prevention and treatment of such complications. The various measures, such as carbon dioxide inhalations, posture and bronchoscopy, which have previously been advocated as prophylaxis in this regard will be briefly mentioned, because these measures are of importance and also because a combination of several or all of the therapeutic measures is frequently necessary. Attention will be particularly called to intratracheal suction by means of a catheter introduced through the nares. Its purpose is the same as bronchoscopic aspiration, and it may be used either in preference to bronchoscopy, to supplement bronchoscopy when repeated aspirations are necessary, or as an alternative to bronchoscopy when the latter is not available. The term "intratracheal suction" will be used in this article to mean the application of actual suction for the removal of intratracheal or intrabronchial secretions, whether by bronchoscopy or by an intratracheal catheter.

The writer's interest in this subject was aroused by the constant necessity of preventing the retention of bronchial secretions in postoperative cases of pulmonary suppuration. If adequate drainage of these secretions is not provided, the patient is prone to develop either an extension of the disease or an aspiration pneumonia in previously unaffected portions of either lung. To prevent the development of such complications, it is necessary that drainage of the bronchial tree be free at all times. When patients are willing to coöperate, and when they are not so ill that they are unable to coöperate, free drainage can be maintained by postural methods, such as the Trendelenburg position, as advocated by Gray,[8] by rolling the patient from side to side as advocated by Sante,[13] by hyperventilation with 15 per cent carbon dioxide inhalations, by sufficient narcotics to control pain and promote effective coughing, and lastly by well directed nursing care, so that patients will be assisted to cough and expectorate freely when necessary. In other instances intratracheal suction, either by bronchoscopic aspiration or by an intratracheal catheter, must be employed, occasionally as an emergency measure when patients are literally drowning in their own secretions. The results of intratracheal suction have, at times, been dramatic in their suddenness. Thus,

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patients with tracheal râles prior to the procedure may have been dyspneic and cyanotic and at times unconscious because of anoxemia, in spite of an optimum oxygen supply by intranasal catheter or an oxygen tent. Such patients, if a too extensive pneumonic involvement has not already occurred, can be rapidly restored to consciousness, quiet breathing and a normal color, merely by the removal of the obstructing secretions so that a normal airway is provided. The methods which have been successfully applied in the postoperative management of thoracic surgery patients have been found to be of equal advantage in the treatment of bronchial stasis occurring in general surgery patients. This article is presented primarily because of the wide application of these measures in general surgical cases. The treatment of postoperative complications arising from septic and aseptic pulmonary emboli will not be considered, inasmuch as the etiologic factor is quite distinct from the complications which are directly the result of retained bronchial secretions. However, when bronchial secretions arise as a result of emboli, their management is the same as when the secretions are due to other causes.

Causes of Retained Tracheobronchial Secretions.—Troublesome secretions within the tracheobronchial tree after operation may be due to aspiration of oral and pharyngeal secretions, either during or immediately following the operation. More often they are actual secretions which have normally formed within the tracheobronchial tree or which have resulted from predisposing causes such as the irritating effect of the anesthetic agent, chronic bronchitis, mild bronchiectasis or other pulmonary or bronchial conditions productive of secretions. The stasis of normal secretions is in itself sufficient to produce an inflammatory reaction which results in a bronchial exudate.

The retention of secretions may be due to several causes, among them being: (1) The inability or unwillingness of the patient to cough and expectorate effectively; (2) the lack of application of helpful measures for aiding cough and expectoration; and (3) improper instruction of the patient regarding the necessity of effective cough and expectoration.

The most important causes of the patient's inability to cough effectively are: (1) Unconsciousness because of anesthetic agents, such as ether, avertin, sodium amytal and too heavy preoperative and postoperative narcotic doses; (2) unconsciousness because of comatose or semicomatose conditions attributable to the patient's age or general condition; (3) insufficient strength because of the recentness or severity of the operation; (4) ineffectual cough due to pain in the operative wound or resulting from upper abdominal binders which may have been applied too tightly so that effective inspiration is prevented; (5) secretions which are too tenacious to be expelled by an otherwise effective cough; and (6) thoracic operations which have produced excessive flaccidity of the thoracic wall.

The postoperative position of the patient before he has regained consciousness from anesthesia is of importance in favoring or preventing the development of postoperative pulmonary complications. As the semi-Fowler position favors the gravitation of oral and pharyngeal secretions into the tracheo-

bronchial tree and the bases of the lungs, and as it favors stasis of bronchial secretions unless the patient is able to cough effectively, the Trendelenburg position is preferable, unless it is contraindicated because of actual or potential infection within the peritoneal cavity.

The constant occurrence of viscid bronchial secretions in cases of atelectasis has been stressed by Lee, Tucker and Clerf[11] in one of the first publications on pulmonary atelectasis. Because of the thick, mucoid, tenacious character of this bronchial secretion and the inability or disinclination of the patient to clear this secretion from the bronchi, it accumulates in the deeper portions of the bronchial tree until at some point or points this stream of mucus completely occludes the lumen. If this occlusion takes place in small bronchioles, a lobular atelectasis occurs; if in a bronchus leading to one lobe, a lobar atelectasis; and if in a main bronchus of either lung, a massive atelectasis.[11] Coryllos[4] believes that great viscosity of the bronchial secretion, so characteristic of bronchial stasis, results from the rapid growth of pneumococci which gives to the bronchial exudate a degree of viscosity sufficient to produce obstruction of small or even larger sized bronchi.

The urgent indications for application of measures to clear the tracheobronchial tree are several. These indications may consist of a wet but unproductive or incompletely productive cough, tracheal or bronchial râles, rhonchi or wheezes heard with or without the stethoscope, or signs of atelectasis or pneumonia as detected either by physical or roentgenologic examinations. With regard to roentgenologic examinations, it is frequently difficult, with a portable roentgenologic unit, to differentiate between a postoperative bronchopneumonia and a lobular atelectasis, due to retained secretions or a mucous plug. The clinical picture may aid in the differentiation and, in occasional doubtful cases, it is usually advisable to bronchoscope the patient to be certain that a condition which can be relieved by bronchoscopy is not being overlooked.

Prevention of Retained Secretions.—Several of the methods of prevention of postoperative pulmonary complications have been briefly mentioned. These will be more fully discussed and additional measures will be mentioned. Preoperatively, it is obviously advisable that a dental prophylaxis be given when indicated and when the operation is not one of emergency. Should the patient have a small amount of sputum, he should be encouraged to clear the tracheobronchial tree thoroughly before operation. In many cases of pulmonary diseases, it is necessary to employ a postural drainage for this purpose.

When anesthesia is complicated by excessive pharyngeal secretions, it is preferable that the operation be carried out with the patient in the Trendelenburg position when possible. Should it be known that numerous secretions are being aspirated into the trachea during operation, it may be advisable for the anesthetist to insert a large intratracheal catheter and to administer the anesthetic agent through this catheter. Periodic aspirations by the insertion of a smaller catheter through the larger one can then be carried out during the course of the operation. In other instances of aspirated secretions in

which it is not necessary to resort to the intratracheal method of administration of anesthesia, it may be advisable to bronchoscope the patient immediately after operation, should an avertin or ether anesthesia prevent him from awakening immediately on completion of the operation. As anesthetic agents which produce a long period of unconsciousness after operation are highly conducive to the development of postoperative complications it is preferable that other agents, which allow the patient to awaken promptly after operation, should be employed if they provide an equally satisfactory anesthesia. When the patient awakens immediately after the operation, the anesthetist should, habitually, instruct the patient to cough and clear the tracheobronchial tree as thoroughly as possible.

Postoperatively, the use of the Trendelenburg position[1] is of importance. This position should be maintained until the patient regains consciousness and it is preferable to maintain it for at least 24 hours, as suggested by Gray. Should a patient raise considerable sputum after operation, it may be advisable for this position to be continued for an even longer period. Many patients, however, are able to cough more effectively when they are in the semi-Fowler position than when they are in the Trendelenburg position. Therefore, if the patient is conscious, the particular position which is best suited to the individual patient should be employed.

Coughing and expectoration can be aided when the patient is in the Trendelenburg position by having him lie on one side for fifteen or more minutes and then on the other side in order to allow alternate clearing of the uppermost lung. The lateral position also favors the ciliary drainage of secretions from the uppermost lung. If one lung is known to be, or to have been, the site of an atelectasis, suppurative pneumonitis, bronchiectasis or bronchopneumonia, this lung is kept uppermost for approximately twice as long as the contralateral lung. When the patient is conscious and has no bronchial secretions, it is permissible to allow him to assume the dorsal recumbent position, but even under these circumstances, it is advisable to change to the lateral position from time to time to prevent hypoventilation of the bases of the lungs.

The routine use of 15 per cent carbon dioxide and 85 per cent oxygen inhalations every two, three or four hours, followed after each inhalation by voluntary assisted cough, is advocated as a prophylactic measure even when secretions are not present. When secretions are present, drainage is facilitated by the administration of carbon dioxide immediately after changing the patient to the lateral position. The carbon dioxide should be so administered that it will cause hyperventilation, and again the patient should be encouraged to cough and expectorate after each administration. Not only does the hyperventilation tend to clear the tracheobronchial tree by means of the increased inflow and outflow of air, but the carbon dioxide specifically produces relaxation of the bronchial musculature[2] and consequent enlargement of the lumen of the bronchi which facilitate the dislodgment of obstructing secretions. Coryllos[4] is of the opinion that, under the influence of carbon dioxide, the

bronchial exudate tends to lose its viscosity and to become transformed into a thin frothy secretion. A word of caution might be mentioned regarding the use of carbon dioxide inhalations, if they are given when the patient is in an improper position and are not followed by voluntary cough. For instance, as Lubin[12] has stated, when patients with a lower lobe atelectasis are given carbon dioxide inhalations in the upright position without subsequent appropriate postural changes, the secretions already present in the lower bronchial stems will gravitate more deeply into the lower lobes. This is particularly true when the secretions are thin.

When the patient is instructed to cough, it is frequently advisable for the nurse to assist in the procedure by supporting painful wounds, such as an upper abdominal incision, by means of gentle pressure with a hand on each side of the abdomen so that less tension is placed upon the incision during the cough. If the necessity of effective coughing is explained to the patient, he will usually coöperate more fully than otherwise, even when coughing is accompanied by considerable pain.

The judicious use of narcotics to prevent excessive pain during coughing is of importance, and the patient should be especially encouraged to cough as soon as each individual dose of the narcotic has produced its maximum effect. Care should be taken that the amount of the narcotic should not be sufficient to abolish the cough reflex or to cause prolonged periods of sleep or drowsiness when secretions are present. Steam inhalations with the addition of menthol, and one of the many expectorants may be advantageously employed when the secretions are excessively tenacious. Atropine should not be used to "dry up" the secretions, as it will only cause bronchial secretions to become thicker than otherwise and drainage will be less efficient.

It may be imagined, from the stress that has been placed upon the necessity for adequate cough and expectoration, that patients are considerably exhausted by the procedure. Such is not the case, and it should be realized that a few timely and effective coughs at periodic intervals are much less tiring than the more or less constant, irritative and ineffective type of cough which occurs when tracheobronchial secretions are being retained. The ineffective type of cough is particularly wearing on a patient and it is also objectionable because it tends to force the secretions farther out into the bronchial tree and parenchyma.

Indications for Intratracheal Suction.—As careful attention in carrying out the details of the above mentioned measures usually suffices to provide adequate drainage of the bronchial tree, intratracheal suction is usually unnecessary. Intratracheal suction is indicated, however, when the cough remains wet and unproductive, either because the patient is unable to coöperate, due to insufficient strength or unconsciousness, or rarely because of unwillingness to coöperate. The significance of a wet unproductive cough should not be underestimated, in that it is a most important sign which indicates that secretions are still present and are not being effectively expectorated. When the patient is unconscious, one cannot always rely on this sign, as coughing

may be absent unless the cough reflex is provoked, as by aspiration of the pharynx. In the unconscious patient, therefore, the diagnosis of retained secretions can at times be made only by auscultation of the chest, in order to determine if rhonchi, wheezes or a wet type of breathing is present, or by listening for these signs with the stethoscope placed in front of the patient's mouth. More often, when retained secretions are present in an unconscious patient, tracheal râles and noisy respirations are audible when the listener stands a considerable distance from the patient's bed. The diagnosis of retained secretions is then obvious. The presence of cyanosis in a conscious or unconscious patient is suggestive of an impaired respiratory pathway when the cyanosis cannot be explained by other causes.

It is impossible to be dogmatic about the relative indications for bronchoscopic aspiration or aspiration with an intratracheal catheter. Both methods have a place. Frequently they can be used interchangeably and it is often a matter of election as to which should be used. The writer uses both methods and has no strong preference for either one. When a single aspiration will probably be sufficient, bronchoscopy may be preferred, in that it is the more certain of the two methods as it provides actual inspection of the interior of the tracheobronchial tree. Bronchoscopy thereby enables the surgeon to be certain that complete evacuation of secretions has been obtained and that a mucous plug has not been overlooked. For the same reason, bronchoscopy is probably preferable when a definite atelectasis is present. Bronchoscopy also allows the swollen inflamed mucosa to be shrunken with applications of a solution of equal parts of 1-1000 adrenalin and 10 per cent cocaine. However, bronchoscopy may possibly cause a greater degree of trauma to the tracheal and bronchial mucosa and thereby cause the further formation of secretions. This is undoubtedly of importance in some unconscious patients for whom it is necessary to resort to intratracheal suction every four or six hours in order to maintain adequate drainage. In such cases, the intratracheal catheter is the preferable method, although it may be advisable to carry out a bronchoscopic aspiration as the initial procedure. In most cases in which intratracheal suction is necessary, a single aspiration or several aspirations with the intratracheal catheter will suffice, and it is then unnecessary to resort to bronchoscopy. As bronchoscopy is more strenuous for a critically ill patient, intratracheal catheter suction is the preferable procedure in such instances. The deciding criterion may be the method which is the more quickly available. It is not unusual that an aspirating machine is already at hand to allow the nurse to remove pharyngeal secretions, and as a sterile No. 16 French soft rubber urethral catheter is usually present on the catheterization tray, the catheter method of suction can be employed without delay. This method is especially advantageous at night, when a delay in assembling the bronchoscopic equipment may be unavoidable, and also in instances in which a bronchoscopist is not available.

Method for Use of the Intratracheal Catheter.—An ordinary No. 16 French soft rubber urethral catheter, or preferably a Robinson urethral

catheter of similiar size which differs in that it has a double instead of a single opening, is connected to the suction machine with a glass connecting tube and a fairly stiff long rubber connecting tube. The catheter should be relatively new so that it will not have become unduly softened by repeated sterilizations. It is introduced into the nares and is directed posteriorly until it can be felt to touch the arytenoids. The presence of the catheter at this level usually stimulates the cough reflex. The catheter is then withdrawn slightly and is next quickly advanced into the trachea simultaneous with the expiratory phase of the cough or during the deep inspiration which follows it. If the patient tends to swallow the catheter due to an inactive cough reflex, this can be prevented by slightly withdrawing and advancing the catheter several times in quick succession, in order to stimulate the cough reflex. Should the cough reflex still be absent, as occasionally occurs in deeply unconscious patients, it can as a rule be stimulated by carrying out the above maneuver with the suction turned on. The introduction of the catheter into the esophagus can usually be avoided if the surgeon remembers to advance the catheter during the expiratory phase of the cough, for the obvious reason that a person cannot swallow and cough at the same time.

When the diagnosis of retained secretions has been accurately made, a considerable amount of thick, tenacious purulent secretion will usually be obtained as soon as the catheter enters the trachea. The amount of secretion obtained is frequently surprisingly large. Furthermore, the presence of the catheter in the trachea incites further coughing which in turn dislodges bronchial secretions into the trachea where they can be removed by suction. The procedure so far is carried out with the patient in the recumbent position and with the foot of the bed elevated. After the trachea has been cleared, the catheter is introduced farther so that it enters the primary bronchi. When the patient is recumbent the catheter usually enters the right stem bronchus; it is usually advisable to turn the patient on the left side in order to introduce the cathether into the left stem bronchus. The smaller bronchi are not aspirated, but the forceful coughing which accompanies the procedure tends to expel their secretions into the main bronchi or trachea where they can be aspirated. The removal of secretions from the smaller bronchi can be aided by turning the patient from side to side, once or twice during aspiration of the stem bronchi, so that posture will aid the cough in dislodging the secretions from the smaller bronchi. The foot of the bed, meanwhile, is kept elevated. When the catheter has been advanced well into the stem bronchus, the outer end of the catheter will be found to be within three or four inches of the nose. The aspiration is continued usually for one or two minutes, depending on the amount of secretions present, and until no further purulent material is seen coming through the glass connecting tube.

The secretions obtained by intratracheal suction are quite thick and tend to plug the catheter and rubber connecting tube. In spite of this, it is usually possible to keep the aspirating system clear by rapidly pinching and

releasing either the connecting tube or the catheter in order to cause a sudden stoppage and reapplication of the suction. If the system becomes plugged and the above maneuver does not suffice, the glass connecting tube is disconnected from the catheter, so that sterile water can be sucked through the glass and rubber connecting tubes to reëstablish their patency. If, after reconnecting the system, the catheter itself is found to be plugged, it is necessary to remove it temporarily so that it likewise can be cleared. As the suction tends to provoke excessive coughing and slight cyanosis, it is usually necessary to apply suction intermittently by repeatedly pinching the catheter for a period of several respiratory phases from time to time, so that the patient will not be too much upset by the procedure.

A reaccumulation or reformation of secretions is to be expected, even though the bronchial tree has been completely cleared of secretions at the first aspiration. The patient's condition will frequently have improved sufficiently following one or two aspirations so that pulmonary aeration, voluntary cough and expectoration will subsequently be sufficient to keep the tracheobronchial tree clear. In occasional instances it may be necessary to repeat the aspirations at intervals of four, five or six hours over a period of one or more days until the patient is able voluntarily to cough and expectorate effectively. The insertion of the catheter causes a mild degree of trauma to the lower pharynx, larynx and tracheobronchial tree and therefore it is unwise to employ the procedure more often than is actually necessary. Furthermore, the insertion of the catheter has the theoretical objection of contaminating the bronchial tree with pharyngeal organisms. Clinically we have seen no ill effects from this.

The number of cases in which intratracheal suction has had to be employed at the University of Michigan Hospital has been relatively few, but the various types of cases in which it has been used have been diversified. These postoperative conditions have included partial gastrectomy, cholecystectomy, thyroidectomy, prostatectomy, splanchnicectomy and osteoplastic bone flaps as well as postoperative pulmonary cases. The thoracic and postoperative abdominal conditions, especially those with an upper abdominal incision, are prone to develop retained secretions because of pain on coughing. The temporary unconscious states that may result from intracranial operations and operations on the urinary tract in the presence of uremia, have also been found to favor the retention of secretions.

ILLUSTRATIVE CASE REPORT

Case Report.—A male, age 58, had had a slight chronic cough which was productive of a small amount of greenish and occasionally foul sputum. On admission the amount of sputum varied between 3 and 34 Gm. daily. Occasional râles were noted at the base of the left lung and over the right middle lobe. A roentgenogram (Fig. 1A) showed pulmonary emphysema and increased bronchovascular markings at both bases, more so on the left side.

Operation.—October 22, 1936. Under nitrous oxide and oxygen anesthesia, a large carcinoma involving the pylorus and lower portion of the stomach was found. A resec-

tion of the lower two-thirds of the stomach and a Pólya type of gastro-enterostomy were performed. The patient's convalescence was satisfactory until the evening of the tenth postoperative day when a disruption of the wound occurred. A secondary closure of the wound was promptly effected under light nitrous oxygen anesthesia. The duration of the anesthesia was 20 minutes and the patient reacted promptly. He was inadvisedly placed

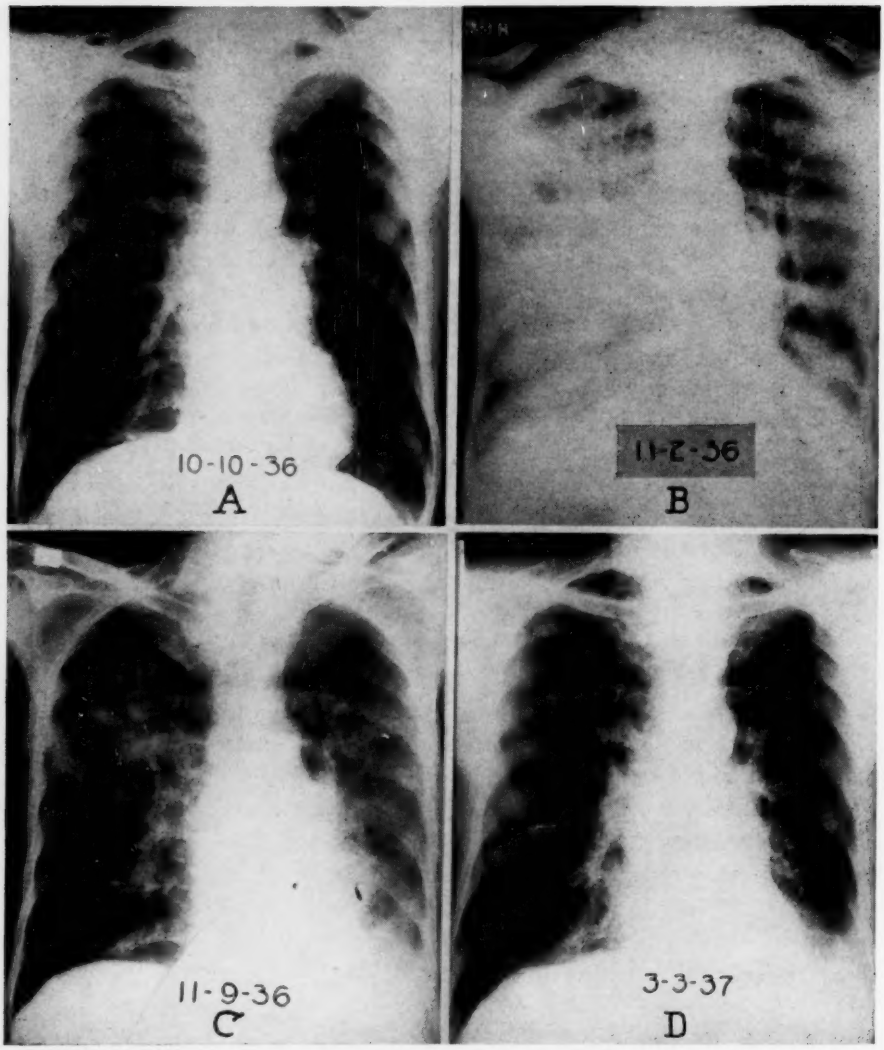

FIG. 1.—(A) Preoperative roentgenogram, October 10, 1936, showing bilateral pulmonary emphysema. The increased bronchovascular markings in both bases, especially the left, suggest a chronic basilar pneumonitis with probable slight bronchiectasis.

(B) Portable roentgenogram, November 2, 1936, three and one-half hours after the development of coma and one and one-half hours after intratracheal suction was instituted. Consciousness had returned at the time this roentgenogram was made. An extensive pneumonic involvement has occurred throughout the right lung and in scattered areas in the left lung.

(C) Roentgenogram, November 9, 1936, showing that a marked clearing of the pneumonitis in the right lung has occurred, but much residual parenchymal infiltration remains in both upper pulmonary fields, especially the right. The left costophrenic pleuritis is evident.

(D) Roentgenogram, March 3, 1937, showing a further improvement of the pneumonitis. There is a parenchymal scarring on the left, and a slight diffuse interstitial pneumonitis in the right upper lobe. The left costophrenic pleuritis is essentially unchanged.

in the semi-Fowler position, and carbon dioxide inhalations and assisted cough and expectoration were unintentionally omitted. His condition was apparently satisfactory until early the following morning. The nurse's note states that at 6 A.M. a "large amount of mucus was present in the throat." About 7 A.M. the patient became suddenly dyspneic and comatose, the pulse was rapid and thready, the blood pressure dropped to 60/40, and the skin was cold. Intravenous fluids (gum acacia, and 5 per cent glucose) and ephedrine were immediately given to combat shock, and the patient was placed in an oxygen tent. The flow of oxygen into the tent was at the rate of eight liters per minute.

When he was seen by the writer in consultation shortly afterwards, the patient was still unconscious. Tracheal râles were audible at a considerable distance, numerous rhonchi could be heard in both lungs and the patient was deeply cyanotic in spite of the oxygen. It was obvious that he was drowning in his bronchial secretions. An intratracheal catheter was quickly introduced according to the technic described above and a tremenduous amount of thick, purulent secretion was removed. The aspiration was carried out with the patient in the Trendelenburg position, and he was turned first on one side and then on the other to allow the removal of secretions from both bronchial trees. Consciousness returned about 15 minutes later, and, shortly thereafter, a roentgenogram was taken with a portable unit (Fig. 1B). The patient's condition improved rapidly, being aided by a blood transfusion. However, he did not regain sufficient strength to cough effectively and a "wet cough" persisted. It was, therefore, necessary to continue intratracheal suction every two hours for the following 24 hours and every four hours for the next two days. At each aspiration 10 to 30 cc. of purulent material was removed. The catheter was introduced with the patient in the recumbent position and he was rolled from one side to the other during each aspiration. Between aspirations he was changed from one lateral position to the other. Because of the greater pneumonic involvement of the right lung, this side was kept uppermost for approximately twice as long (one hour) as the contralateral side (one-half hour) so that drainage from the right lung would be facilitated. The foot of the bed was elevated for the first 24 hours and the oxygen tent was kept in place for 48 hours. Voluntary cough became progressively more productive, beginning on the afternoon of the first postoperative day, but as the patient's strength had been so exhausted by the second operation, and by the critical complication which followed it, the cough effort did not become completely effective until the third postoperative day when intratracheal suction was discontinued. A roentgenogram (Fig. 1C) on the eighth postoperative day showed marked clearing of the pneumonitis in the right lung and a small left pleural effusion. The patient was discharged from the hospital 26 days after the secondary closure of the wound.

He returned for examination two and one-half months later, at which time further improvement of the pneumonitis was evident (Fig. 1D). The minimal left pleural effusion had remained sterile and relatively unchanged in amount during the interval.

This case is presented to illustrate the relief of an apparently hopeless complication by the use of intratracheal suction.

SUMMARY AND CONCLUSIONS

The constant maintenance of adequate drainage of the tracheobronchial tree is essential in the prevention and effective treatment of postoperative pulmonary complications. Many of the so-called postoperative pneumonias are due to the aspiration of pharyngeal secretions or to the retention of tracheal or bronchial secretions. Postoperative complications in such instances can usually be avoided by keeping the tracheobronchial tree constantly

free of secretions. Such measures as posture, carbon dioxide inhalations, assisted cough and expectoration and the use of narcotics, inhalations and expectorants have been discussed. The indications for intratracheal suction, which is employed by means of bronchoscopy or by an intratracheal catheter introduced through the nares, have been described. Particular attention has been called to the advantages and the method of use of the intratracheal catheter. Although it is not always possible to prevent the development of postoperative pulmonary complications, it is believed that the incidence and the severity of such complications can be greatly minimized by following out the preventive and therapeutic measures described.

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SPONTANEOUS CHOLEDOCHOGASTROSTOMY AND CHOLECYSTOGASTROSTOMY

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THE observation of an instance of spontaneous anastomosis between the short proximal end of a traumatically severed strictured common bile duct and the pylorus of the stomach, and two cases of spontaneous cholecystogastrostomy, is unusual.

Benign strictures of the bile ducts may result from inflammatory processes and occasionally from the passage of gallstones, but injury to the common duct from operative trauma is the more common etiology. Previous to 1914, benign strictures of the common duct were infrequent and were recorded individually. This was probably due to the fact that cholecystostomy was the operation of choice rather than cholecystectomy or common duct drainage. Since that time a tremendous literature has developed on the reconstructive surgery of the extrahepatic bile ducts. This is not only the result of forward steps in reparative surgery, but is also due to advances in the technic of operating upon malignant lesions.

The first cholecysto-enterostomy was reported, in 1882, by Winiwarter. In 1892, Doyen performed an end-to-end anastomosis of the common duct. Murphy,[7] in 1892, performed a cholecystoduodenostomy employing the Murphy button, with an excellent result. Jenckle reported a case in which he performed a hepaticocholangiogastrostomy, but the result was not recorded. Various types of anastomoses between the common duct and the stomach, duodenum, small bowel, or colon have been advanced. However, we have been able to collect only seven cases of *spontaneous* internal biliary fistula in 6,000 autopsies at the Cook County Hospital. One was due to perforation of a carcinoma, and one to perforation of an ulcer of the stomach. The remaining five were the result of perforation of stones into the duodenum. In none of the cases was the condition diagnosed during life, but was recorded incidentally at autopsy, with the exception that gallbladder histories were obtained in three cases, and stones were demonstrated clinically in two.

Judd and Burden[4] have reported 153 cases of spontaneous internal biliary fistulae which required operative relief, but were able to diagnose the condition preoperatively in only two instances. They believe that the presence of a fistula is a complication rather than a cure of the preexistent pathology. The presence of a fistula with adequate drainage becomes complicated only as time passes, when the tract becomes progressively shrunken in caliber due to the

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presence of active infection or to latent cicatrization. Pohlandt[9] demonstrated such a spontaneous cholecystogastrostomy by using a thin mixture of barium orally, followed by the injection of air into the stomach. He states that in such cases the bile passages are occasionally outlined by taking a flat roentgenogram of the abdomen, and that air can be demonstrated in the gallbladder and ducts if a fistula exists. This procedure was tried in our case without success, probably because the fistulous opening was too small.

Forty-four cases of internal biliary fistula have been diagnosed preoperatively, according to Candel and Wolfson, who demonstrated a cholecystocolostomy by the presence of air in the bile passages. It is difficult to demonstrate choledochogastric fistulae by such an opaque medium as lipiodol, since the stomach cannot be filled under pressure. We have used 7 per cent sodium bromide solution as a contrast medium, from which there was no ill effect.

Methods of Corrective Anastomosis: In instances in which the diagnosis of a choledochogastric or intestinal fistula has been made preoperatively, or in which the condition is found unexpectedly at operation, certain prosthetic measures may occasionally be employed.

When insufficient or no common duct remains, one of several procedures may be possible. The rubber tube is employed most widely[2]; one end may be placed in the duct and the other into the stomach or duodenum,[1] eventually passing spontaneously into the bowel. A modification of this method has been suggested by Hoche,[3] in which the tube, placed into the duodenum, has several openings in its wall, allowing bile to escape into the duodenum; the distal end of the tube is brought out through the abdominal wall from a point lower in the duodenum, so that the tube may be withdrawn externally after several weeks, and the residual duodenal fistula allowed to close. This method, however, occasionally results in a persistent duodenal fistula. The tube must have a large lumen to prevent the precipitation of bile salts and pigments and thus block the biliary tree. Tubes may pass into the bowel before the duct heals and thus predispose to stricture formation. Absorbable tubes of gelatin, and more recently absorbable tubes of magnesium,[8] have served as prostheses. Williams, in 1914, used the fistulous tract, formed by the drainage of the common duct to the anterior abdominal wall, for transplantation into the duodenum. Lahey,[5] Lilienthal,[6] and Walters[12, 13] have used these external fistulous tracts in cases where there was little or no common duct present. This method does not give uniformly satisfactory results.

Experimentally, in dogs, plastic tubular flaps have been taken from the mucosa of the stomach and anastomosed with the gallbladder.[10] In reviewing the literature, we find that Stubenrauch,[11] in 1906, used a full-thickness tubular flap of the pylorus of the stomach and anastomosed this to the gallbladder successfully. To our knowledge, there have been no other reports of this procedure. Gohrbandt[2] has anastomosed the intrahepatic bile duct to the stomach by dilating the duct and using a rubber tube as an intermediary. He has also punctured the liver with a trochar, and into this opening has inserted a rubber tube, followed by anastomosis of the liver to the stomach over the tube.

Case Reports

Case 1.—A white female, age 38, presented herself in March, 1928, with the history of having suffered intermittent pain in the right upper quadrant for three days, which had become progressively worse. It radiated to the back and right scapular region, and was followed by nausea, repeated vomiting and jaundice. The past history was that of the occurrence of a similar pain in the right upper quadrant of the abdomen every two or three months for the previous year. Bed rest and occasional opiates were necessary for relief. Selective dyspepsia for fats and fresh fruit was present. The patient had had typhoid fever 21 years previously.

Physical Examination revealed a fairly well developed white woman who was mildly jaundiced. The liver edge was palpable two fingers below the costal margin. The gallbladder region was exquisitely tender. Gallbladder visualization revealed five opacities present below the transverse process of the second lumbar vertebra, which were interpreted as stones. The icteric index was 15 per 100 cc. of blood serum and the urine showed bile. All other laboratory findings were negative.

Operation.—April 24, 1928: A transverse subcostal incision was made and a cholecystectomy performed. The gallbladder contained 25 stones and was 3 Mm. thick. Two gauze drains were inserted. After the drains were removed, the wound failed to close and continued to drain bile for six weeks. Cessation of the drainage was immediately followed by a chill, fever, and progressive jaundice. A diagnosis of common duct stone with obstruction and ascending cholangeitis was made.

Second Operation.—June 28, 1928: An incision was made through the existing transverse subcostal scar. The common duct was explored, a stone removed, and a T tube inserted into the duct. Drainage was allowed to continue for six weeks.

The patient was well for one year, when she returned with symptoms of pain and mild jaundice which were treated conservatively with calomel and magnesium sulfate. The attacks were mild in nature but would recur every three or four months in spite of dietary regimen. Between these episodes the patient felt comfortable. She presented herself to the Gynecologic Department in 1933, at which time a hysterectomy was performed. In December, 1934, the patient developed a progressive jaundice associated with severe pruritus.

Third Operation.—January 11, 1935: After proper preoperative preparation with blood transfusions, glucose, and calcium, a third transcostal incision was made. The common duct was dissected out of a mass of adhesions and a benign stricture of it was found; the two-thirds of the duct distal to the stricture was completely obliterated by cicatrization. The liver was swollen, a mottled, brownish-green in color, with a rounded edge. Since insufficient common duct remained proximal to the stricture into which a T tube could be placed, it was thought best to attempt the formation of an external biliary fistula whose external orifice could later be transplanted into the stomach or duodenum. With this in view, a catheter was inserted into the proximal end of the common duct and external drainage was instituted. However, notwithstanding the fact that all persons had been instructed as to the dangers of removing the tube, on the sixth postoperative day, an attendant accidentally pulled the catheter out while arranging the bed clothing. Since jaundice was expected to return, the patient was kept in the hospital for two months, but although the wound closed within two weeks there was no occurrence of either jaundice or pain. The stools were dark greenish-brown in color.

The patient left the hospital March 17, 1935, and remained perfectly well for three months, at which time the previous symptoms returned. These began as an ache in the right upper quadrant, which radiated to the shoulder and was accompanied by nausea, jaundice, and an unbearable pruritus.

Fourth Operation.—July 31, 1935: A transverse subcostal incision was made, for the fourth time, through the old scar, and after much difficulty the common duct was

isolated and explored. Parenthetically, it is interesting to note that up to this time no herniation had resulted following the repeated use of the transverse subcostal incision. The fascial layers were all fused; and the parietal peritoneum was adherent to the anterior surface of the stomach and transverse colon. After freeing the adhesions and dissecting down to the region of the common duct, it was only possible to identify the duct by needle aspiration. The stomach was separated with difficulty from the region of the duct, and a fistulous tract was identified extending between the lateral aspect of the proximal end of the common duct and the lesser curvature of the stomach at the pyloric junction (Fig. 1).

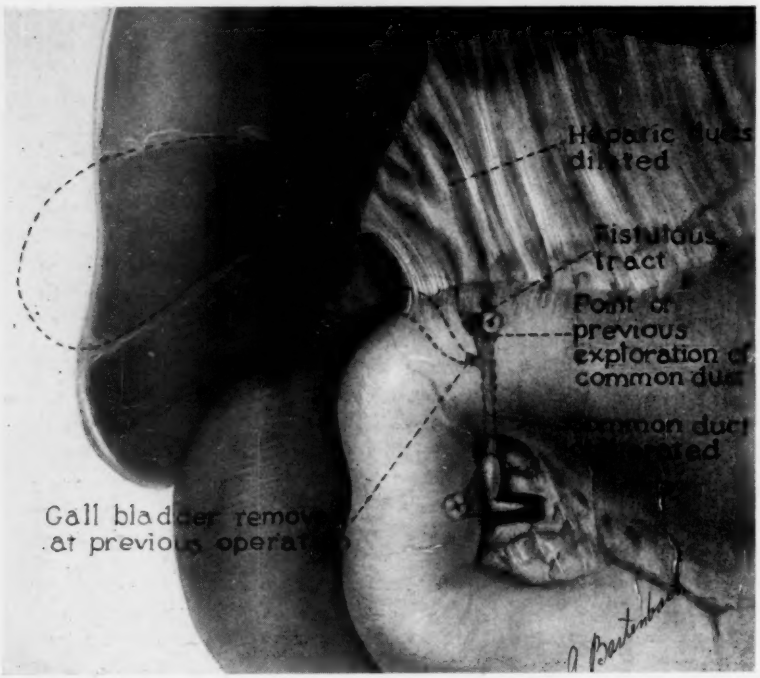

FIG. 1.—(Case 1.) Spontaneous choledochogastrostomy: Illustrating the fistulous communication between the proximal common duct and the stomach. The dotted lines indicate the previous position of the gallbladder and common bile duct whose distal portion previously had become obliterated following common duct drainage.

It would seem that the lumen of the fistula had originally been sufficiently large to carry the bile into the stomach, but after four months the lumen had become so small that jaundice supervened. It is difficult to explain the mechanism of this fistulous tract, which formed without any underlying prosthesis or the ulceration of a stone, and within a very short period of time. The gastric fistula was closed by imbrication, and a Y tube was placed into the right and left hepatic ducts with the hope of forming an external fistulous tract that could subsequently be implanted into the duodenum. The patient had an uneventful postoperative course. The jaundice disappeared rapidly, but the icteric index remained elevated for six weeks.

Subsequent infrequent obstructions of the drainage tube would cause back pain that would radiate to the shoulder. This we ascribed to increase of the intrahepatic pressure following the period of inadequate drainage. Radiopaque material injected into the biliary tree revealed the Y tube to be in place. However, in November, 1935, the tube became obstructed, and was spontaneously extruded from the fistulous tract; drainage rapidly ceased and jaundice developed. During the following month the jaun-

dice, however, gradually disappeared, and it was inferred that another anastomosis had formed spontaneously between the common duct and the stomach.

The patient again presented herself in February, 1936, complaining of abdominal pain, intermittent jaundice, clay-colored stools, and pruritus. She continued to lose weight and strength, so that some type of reconstructive anastomosis between the remainder of the common duct and the gastro-intestinal tract appeared to be imperative. Previously, we had outlined a plan of forming a tubular flap from the stomach to anastomose with the proximal common duct, as described by Stubenrauch.

Fifth Operation.—February 10, 1936: For the fifth time, a transverse subcostal incision was made through the old scar, through which, however, at this time a small hernia had developed. The stomach was found intimately adherent to the undersurface of the liver; by sharp dissection a fistulous communication was exposed between the stomach and the common hepatic duct at its point of emergence from the body of

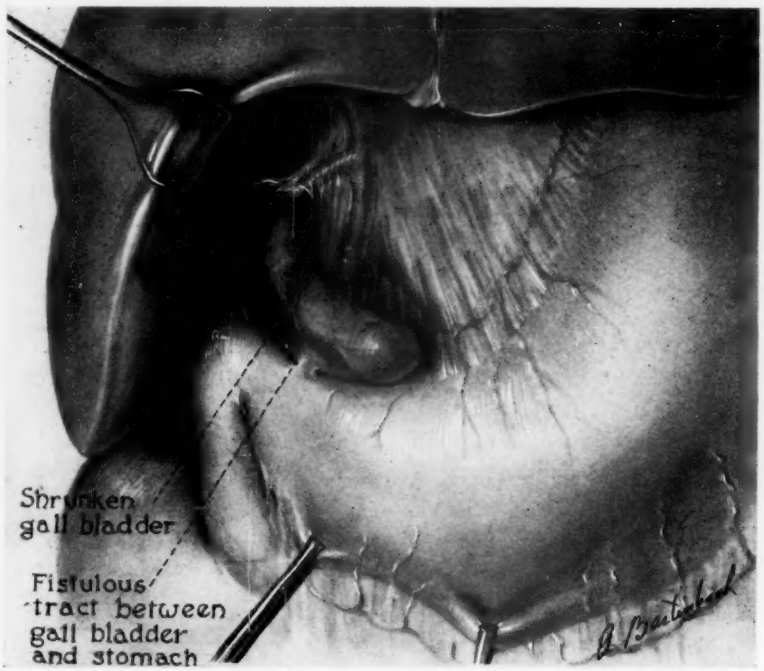

FIG. 2.—(Case 2.) Spontaneous cholecystogastrostomy: Illustrating the fistulous communication between the gallbladder and the stomach, probably at the site of perforation of a previously existent stone.

the liver. Since there was no extrahepatic portion of the common duct remaining, it was technically impossible to perform an anastomosis between it and the stomach. As a procedure of necessity, one arm of a T tube was inserted into the intrahepatic portion of the hepatic duct and the other arm introduced into the stomach. The long end of the tube was brought out of the lateral margin of the abdominal wound. The wall of the stomach was inverted around the intragastric portion of the tube, and the opposed surface sutured to the liver capsule at the T junction of the tube to prevent leakage and to reduce the possibility of later scar contraction diminishing the patency of the fistula. Bile began to drain through the long arm of the T tube, and the stools became greenish in color. The collected bile was dark, viscid, and cloudy, and for this reason it was not reinjected. After eating, the patient complained of pain in the right upper quadrant; however, by allowing the long arm of

the T tube to remain open for two hours after meals, stomach contents regurgitating into the T tube did not obstruct the biliary drainage and the symptoms were relieved. The patient is well and gaining weight at the present time, eight months following the last operation, and eight years after her initial complication.

Case 2.—S. G. The history obtained through an interpreter was that of pain in the right upper quadrant of the abdomen of two weeks' duration, radiating to the right shoulder, accompanied by vomiting. The past history was negative except for an occasional chill followed by fever during the past two years, which the patient attributed to colds. She had had five children.

Physical Examination revealed a thin female with abdominal tenderness localized to the right upper quadrant of the abdomen. The gallbladder could not be visualized on two occasions. A flat roentgenogram of the abdomen revealed no shadows suggestive of stones. The urine contained a trace of albumin. Cystoscopy and pyelography revealed no lesion of the urinary tract. White blood count, 7,300; Wassermann reaction, negative.

Operation.—September 11, 1935: A transverse subcostal incision was made, and a chronic phlegmonous cholecystitis with secondary cicatrization and shrinkage of the gallbladder was found. There were old, dense adhesions between the gallbladder and the stomach. Dissection at the point of apposition between the pylorus and the midportion of the gallbladder demonstrated a spontaneous fistula to exist between these two structures (Fig. 2). There was no evidence of ulcer in the stomach. The proximal common bile duct was dilated, the liver enlarged and discolored, its edge was rounded, and extended three fingers breadth below the costal margin. There were no stones in either the common duct or gallbladder. After liberating the fistula and imbricating the opening into the stomach, a cholecystectomy was performed.

Postoperative Course.—An uneventful convalescence ensued. At a subsequent examination, three months later, she did not complain of any symptoms.

This patient probably had passed stones into the stomach through the spontaneous cholecystogastrostomy; the dilatation of the common duct was no doubt due to the small caliber of the fistulous opening.

Benign biliary fistula into the gastro-intestinal tract may exist unrecognized, and without symptoms, until the fistulous tract becomes narrowed by cicatrization or inflammatory change to an extent sufficient to produce obstructive jaundice. If sufficient infection is present in the retained bile, liver abscesses with a septic syndrome may develop.

Case 3.—For nine years the patient, a white female, age 46, had suffered from intermittent attacks of pain in the right upper quadrant of the abdomen. These pains were sharp, radiated to the right shoulder and around the right costal margin to the back, but were never associated with vomiting, jaundice, or clay-colored stools. About one week before admission to the hospital she suddenly experienced a chill followed by pain in the right upper quadrant of the abdomen. This pain was sharp, burning in character, and radiated to the right shoulder and to the back. During the preceding week she had vomited one or two times each day. On the second day of the attack she had noticed an increasing jaundice with lighter stools and a dark green urine. On entrance into the hospital, she appeared acutely ill, slightly irrational, severely jaundiced, and markedly dehydrated. The liver edge was palpable, and there was tenderness in the gallbladder region. The icteric index was 180; the urine contained considerable bile; the urea nitrogen in the blood was 105 per 100 cc.; creatinin, 1.5 mg. Her temperature reached 104° F. In view of the long history of intermittent attacks of pain in the right upper quadrant, the present attack was interpreted as being due to a stone in the common duct with resultant obstructive jaundice and septic cholangeitis. In

spite of active, conservative treatment, the patient apparently developed cholemia and died after five days, 11 days after the onset of the acute attack.

Autopsy.—Dr. Richard H. Jaffé: The patient was an obese white woman whose skin had a deep yellow color and whose abdomen was slightly distended. The liver was markedly swollen and extended for 4 cm. below the costal margin, was soft in consistency, and a deep olive-green in color. The intrahepatic bile ducts were much dilated and were filled with a thin, dirty-green bile. In the right lobe soft confluent bright yellow areas up to 5 Mm. in diameter were found. The gallbladder was shrunken to about the size of a cherry, and was firmly adherent to the lesser curvature of the stomach. At this region the mucosa of the stomach showed a pinhead-sized opening with everted edges, from which a narrow fistulous tract extended into the lumen of the gallbladder. The gallbladder contained a small amount of mucopurulent material. The hepatic ducts and the common duct were markedly dilated. The common duct meas-

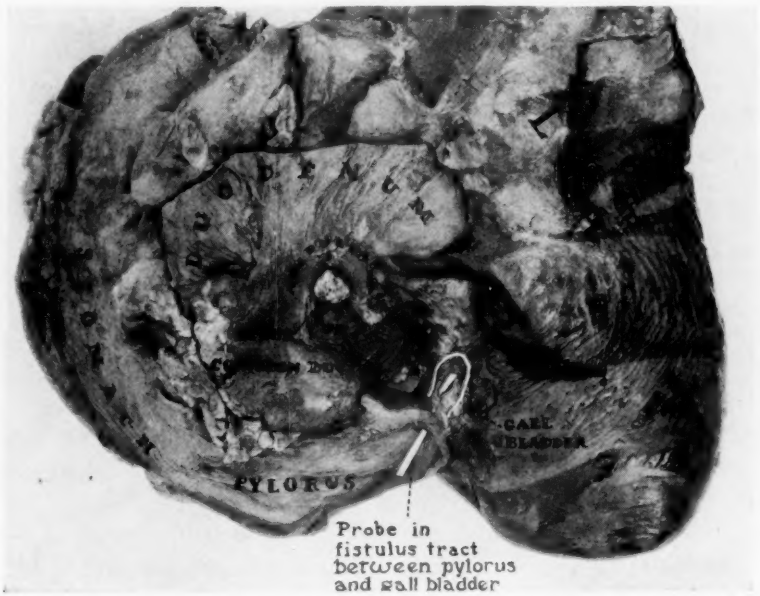

FIG. 3.—(Case 3.) Photograph of the gross specimen of liver, stomach, and duodenum showing a facetted stone in the ampulla of Vater with obstruction and marked dilatation of the common bile duct, and a spontaneous fistula between the gallbladder and pylorus. The gallbladder is shrunken (outlined by white marker) and contains a probe lying in the fistulous tract between the pylorus of the stomach and the gallbladder, probably at the site of passage of a previously existent stone.

ured 25 Mm. in diameter and within the lumen of the duct, above the opening of the pancreatic duct, a facetted light-brown stone measuring 13 Mm. in diameter was present (Fig. 3). The cystic duct was tortuous and moderately dilated. The pancreatic duct was of normal caliber. The pancreas revealed several pinhead-sized opaque, light-yellow areas. The other autopsy findings were those usually found in death from septicemia.

Anatomic Diagnosis.—Obstruction of the common duct by a stone, with marked dilatation of the extra- and intrahepatic bile ducts and ascending cholangeitis; multiple abscesses in the right lobe of the liver, and in both kidneys. Chronic cholecystitis with marked shrinkage of the gallbladder. Spontaneous cholecystogastrostomy.

This case represents one of benign obstruction of the common duct caused by a stone proximal to the ampulla of Vater. The stone has caused stagnation

of the biliary flow with subsequent dilatation of the extra- and intrahepatic bile ducts. There was only this single stone in the common duct, but since it was facetted, other stones must have been previously present which had left the gallbladder either through the common duct, or through the fistulous tract which connected the gallbladder with the stomach. Because of the extreme shrinkage of the gallbladder, this fistulous tract undoubtedly had decreased in size. The stasis of bile in the common duct led to an ascending biliary tract infection, and from this infection multiple abscesses developed in the liver, and later, by way of the blood stream, in the kidneys.

Two factors are responsible for the patient's death: Namely, the severe damage to the liver parenchyma by the long-standing stagnation of the bile flow, and septicemia from the ascending infection of the biliary system. As is usual in cases of benign obstruction of the biliary passages, the gallbladder was small and shrunken. Since the stone was located proximal to the opening of the pancreatic duct, the pancreas was not affected by the occlusion of the common duct. Subterminally a small amount of infected bile had entered the pancreatic duct and had caused multiple foci of fat necrosis.

CONCLUSIONS

(1) Benign biliary fistulae into the gastro-intestinal tract may exist unrecognized and without symptoms other than chronic gallbladder disease until the fistulous tract becomes narrowed either by cicatrization or inflammatory change to an extent sufficient to produce obstructive jaundice. If sufficient infection is present in the retained bile, ascending biliary tract infection may then occur.

(2) There is nothing in the symptomatology in these cases, in which there is an obstructive jaundice clinically, to lead one to suspect the existence of such a fistula.

(3) Diagnosis of the condition is theoretically possible, before obstruction occurs, by the roentgenologic finding of injected opaque material or air from the stomach or duodenum in the biliary passages. This would no longer be a possible finding after the fistula had become obstructed.

(4) Inadequate biliary drainage through a fistulous communication between the common duct and the stomach or duodenum must be recognized as a cause of obstructive jaundice.

(5) Since the condition is obviously infrequent, its presence must be taken as a clinical rarity rather than a frequent cause of obstructive jaundice.

(6) These cases are mechanically amenable to treatment, but, as is true in all cases of obstructive jaundice, the ultimate prognosis is dependent upon the duration and completeness of the obstruction, and the consequent damage to the liver by back pressure or infection.

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STONES IN THE COMMON BILE DUCT*

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THOSE of us who were doing surgery 20 years ago can recall the spirited debates which took place between the proponents of cholecystostomy and cholecystectomy in the treatment of diseases of the gallbladder. As I began to replace the routine cholecystostomy with cholecystectomy, I was immediately impressed (and I presume others must have been) with the fact that convalescence after cholecystectomy was usually much smoother and more rapid than after cholecystostomy. It might be reasoned that the cause of this is that, with cholecystectomy, the body is relieved at once of a source of toxemia. However, I do not believe this is the only reason, nor, indeed, the chief reason. I believe it is the effect of the loss of bile from the body that delays the convalescence in many cases of cholecystostomy.

That excessive loss of bile from the body is deleterious cannot be denied. Hooper and Whipple (quoted by Howell[1]) state that: In the dog, complete diversion of the bile to the surface is followed by the death of the animal in less than a month. Man seems to be more adaptable. Judd[2] has reported two cases of biliary fistula in association with complete stricture of the common bile duct of 12 and 21 months' duration. He did not remark on the condition of the patients. In his discussion, however, he said: "As an adjuvant in cases of chronic biliary fistula, Gerster and Nissen advocated feeding bile collected from the fistula. It is well tolerated and the general improvement, when debility and asthenia become marked, is striking." I, myself, have repeatedly seen cases of biliary fistula develop distressing symptoms, usually loss of weight, great weakness, anorexia, nausea, diarrhea, and a weak, rapid pulse, and have seen these symptoms promptly ameliorated by the administration of bile or the bile salts. At the present time it is my practice to administer bile salts in all cases where there is any considerable bile drainage.

We know that the presence of the bile salts in the intestinal tract is essential for the digestion of fats and believe the bile has other important functions. Walters[3] has published the results of some interesting experiments upon the effects of calcium on the coagulability of the blood in the presence of jaundice. He found that it took approximately twice as much calcium, given intravenously, to raise the blood calcium in dogs who were jaundiced from ligation of the common duct to the same level as it did in normal dogs, and also that about 50 per cent more calcium was required to kill such a jaundiced dog than was required to kill a normal dog. This is evidence that there is a marked deficiency in the body calcium in the presence of obstructive jaundice.

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Rudolph and Cole (quoted by Walters[3]) claim that the oral administration of calcium has no effect on the coagulability of the blood in jaundiced patients while other observers have reported marked calcium effects in other conditions (pleural effusions, edema, *etc.*) from its administration by mouth. This would indicate that, in jaundiced patients, the process of calcium absorption is disturbed. Cushny (quoted by Walters[3]) says that calcium salts are absorbed with great difficulty from the stomach and intestines and that their absorption is facilitated by the fatty acids, with which they combine to form a soap of calcium, which is more readily taken up by the surface epithelium. Herein may lie the explanation of the calcium deficiency which occurs in obstructive jaundice. If the bile salts are absent from the intestinal tract there can be no digestion of fats and so no fatty acids, which Cushny seems to think is essential for calcium absorption. This would suggest that the administration of bile salts might be helpful in jaundiced patients and that the administration of bile salts and fats might be helpful in any form of oral calcium therapy.

The tendency to diarrhea, often of a putrid character, both in cases of obstructive jaundice and in cases of biliary fistula, is well known. Howell[1] attempts to explain this diarrhea as being due to an excessive bacterial decomposition of the nitrogenous constituents of the food which become coated by the undigested fats when the bile salts are lacking, and so are insulated from the digestive action of the pancreatic trypsin.

Obstruction of the common bile duct, due to the back pressure of the confined bile, causes a dilatation of the biliary tree and an impairment of function or, if the obstruction is of a marked degree, atrophy of the parenchymal cells of the liver. In the cases of obstruction from stones there is the added factor of infection. Due to the degree and duration of the obstruction and to the severity of the infection, we have all grades of liver damage, from those which are hardly recognizable to the most marked degrees of biliary cirrhosis, the so-called "livers of surgical delay."

In no field of surgery, perhaps, unless it be that which is concerned with the relief of prostatic hypertrophy, is careful preoperative preparation and equally careful postoperative treatment so essential for success as that of the surgery of the bile ducts. As I have said, the cases of stone in the common duct may come to us handicapped by any degree of hepatic dysfunction, and many of them also have other serious secondary complications, chiefly pancreatitis and renal insufficiency. Many of them present themselves in an acute phase with a highly active cholangeitis or cholecystitis. Fortunately, the acute septic conditions which accompany stones in the common duct are prone to be remittent, and so we can usually tide these acute cases over and operate upon them at a more favorable time. Rarely an emergency operation, usually drainage of the gallbladder must be performed.

The great majority of cases of stone in the common duct are not in need of emergency surgery. They need surgery, but they need carefully planned surgery, undertaken at the right time. The great value of fluids, sugars,

intravenous calcium and transfusions, both as preoperative and postoperative measures, is too well known to need comment. Everything which can be done to build up and conserve the patient's strength should be done. There is just one point at which I seem to diverge from generally accepted principles, and that is in regard to drainage of the common duct after the removal of stones.

Why drain the common duct? In the great majority of cases I think it is entirely unnecessary. I can urge against it, my belief that an excessive loss of bile from the body may have deleterious effects and, in a seriously sick patient, may turn the tide between success and failure. In 20 years I have sewed a tube into the common bile duct just twice—both within the last year. The first was in a woman who had been jaundiced and who had had some pain for two years. The jaundice and pain had begun shortly after a cholecystectomy. At operation I found a chalky mass filling the common and hepatic ducts, just like a stag-horn stone of the kidney, and in front of it, down near the papilla of Vater, a definitely faceted stone, evidently one which had been formed in the gallbladder. The chalky mass in the bile ducts was, of necessity, broken up and removed piecemeal, and I sewed a tube into the common duct, thinking it might provide a means of egress for any particles of the stone that might have been left behind. The second case was in a man who had been having gallstone colics for about three months and who had been jaundiced for about six weeks. The man was much debilitated and had lost considerable weight. At operation I found a small, contracted, thick walled, edematous gallbladder which contained several faceted stones. No stones were found in the common duct. The head of the pancreas was large and hard. It was because of this evident pancreatitis, and the fact that the man had chronic jaundice, that induced me to put a tube into the common duct through the stump of cystic duct, after cholecystectomy. Both of these patients recovered very well, but I am not sure but that their recovery would have been hastened had I omitted the common duct drainage.

A casual survey of the literature has revealed but one article which advocates the closure of the common duct after the removal of stones. Richter and Buchbinder[4] advised the closure of the incision in the common duct and the closure of the abdominal wound without drainage in order to avoid adhesions. Two weeks after the appearance of this article there was a letter of comment from the late Dr. Wm. S. Halsted,[5] from which I quote:

"I have welcomed the communication of Doctors Richter and Buchbinder upon this important subject (Omission of Drainage in Common Duct Surgery). Although undoubtedly not giving the last word, the authors serve the purpose of stimulating controversy on the vital subject of drainage of the common duct—a subject which surgeons in greater part the world over seem to regard as settled.

"The authors emphasize the desirability of closing the abdominal wound without drainage in order to avoid adhesions, taking it for granted, I presume, that it would be superfluous to call attention to the much more serious and

occasionally disastrous results which follow the prolonged loss of bile by way of the incision in the common duct."

Doctor Halsted then went on to explain his method of draining the common duct by a catheter introduced through the cystic duct and finished the letter as follows:

"All we gain, as a rule, by drainage of the common duct is relief of tension. This relief is secured by drainage by way of the cystic duct and tends to secure prompt healing in the line of suture of the common duct. Aside from the deplorable condition of the patient brought about by the great loss of bile, it seems irrational to me to place a drain in the infected common duct through the line of incision into it, with the expectation that primary healing of the wound will take place. Unquestionably, the entire line of suture, contaminated inside and out with pus-producing organisms and further imperiled by the pressure of the tube, has in many instances broken down."

The strange thing to me is that this article by Richter and Buchbinder, and the comment on it by such a master surgeon as was Halsted, should have apparently been passed unnoticed by the surgeons of this country for more than 25 years. My own practice for 20 years has been, except in very few instances, to close the incision in the common duct after the removal of stones. This I effect with the finest of catgut and then place a soft rubber drain close to the line of incision in the duct. I have had no cause to regret this procedure. In a few instances there has been a slight amount of bile leakage, but I have had no mortality. I believe that, if the common duct is closed after the removal of stones, the patients will, in most cases, have an easier, quicker, happier, and safer convalescence.

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APPENDICITIS IN ARMY SERVICE

A REPORT OF TWENTY-ONE HUNDRED CASES

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FROM January, 1931, to October, 1936, 2,100 operations for appendicitis were performed at the Station Hospital, Fort Sam Houston, Texas, with 10 deaths, a mortality of 0.47 per cent. Appendicectomies incidental to other operations are not included. This series is presented as being fairly typical of appendicitis and its operative results as obtained in Army hospitals.

It is generally agreed that early operation will result in a low mortality rate. Our patients are usually admitted early in their illness. We receive them from the Army personnel, officers and enlisted men; their families; from the C.C.C. camp enrollees; and, occasionally, from the Veterans' Administration. In the first two years covered by this report a good many were admitted by the Veterans' Administration. Since then this class of patients has been cared for in Veterans' hospitals. All of this personnel receives its medical care from the Army Medical Department. In most cases they report any illness early; they are entitled to admission to this hospital; and, in general, they enter the hospital without question when advised to do so by medical officers.

Table I shows the age grouping. Our youngest patient was an infant, age two months, with an acute suppurative appendix and our oldest a retired soldier, age 71, with an appendiceal abscess. Both recovered.

TABLE I

AGE GROUPING

Age	Number	Per Cent
0– 5	2	0.09
5–10	34	1.6
10–15	50	2.4
15–20	168	7.9
20–30	1356	64.7
30–40	367	17.5
40–50	100	4.7
50–60	20	0.95
60+	3	0.16

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Table II shows the patients' status. Of the 437 dependents, 271 were women and 166 children.

TABLE II

STATUS OF PATIENTS

Enlisted men	1,085
C. C. C.	349
Veterans' Bureau	149
Officers	80
Dependents of enlisted men	295
Dependents of officers	142
Total	2,100

Tables III and IV give our classification of the types encountered and the number of each type. We realize that this classification is open to argument. For example: The acute catarrhal type, the so-called acute inflammatory type is so classed by the operator; the pathologist may call it suppurative. With us the acute catarrhal type represents the simplest type of acute appendicitis without obvious signs of associated peritonitis. We believe that patients with this form of the disease would, in the main, recover from that particular attack without operation. We further believe that this form of the disease cannot be diagnosed without operation.

TABLE III

DEFINITIONS OF PATHOLOGIC CLASSIFICATIONS

(1) Acute catarrhal—Acute inflammatory process limited to the appendix.
(2) Acute suppurative—Acute inflammatory process not limited to the appendix. Gangrenous type included. Local peritonitis in varying degrees present. Plastic lymph present. Free fluid has seropurulent appearance. Not ruptured.
(3) Ruptured with peritonitis—Varying degrees of peritonitis. No abscess formation.
(4) Ruptured with abscess formation.
(5) Chronic or interval—Evidence of previous attacks—old adhesions present. No acute inflammation.

TABLE IV

PATHOLOGIC CLASSIFICATION

	Number in This Series	
	Cases	Per Cent
(1) Acute catarrhal	1,157	55.24
(2) Acute suppurative	567	26.84
(3) Ruptured with peritonitis	54	2.58
(4) Ruptured with abscess	36	1.72
(5) Chronic or interval	286	13.62
Total	2,100	

The acute suppurative and gangrenous types are grouped under the one heading of acute suppurative—the severe fulminating type of the disease. This type probably has some mechanical or obstructive element connected

with the pathology plus the infection. These appendices will quickly rupture without operation and especially represent the type in which early operation will keep mortality statistics low. In the third class no attempt has been made to classify the degree of peritonitis present as localized or spreading.

We think that the chronic or interval cases represent, in the main, patients who have had previous attacks of the acute catarrhal type with resultant pericecal and peri-appendiceal adhesions.

TABLE V

TYPE OF INCISION

Type	Cases	Per Cent
Transverse	1,129	53.6
McBurney	397	18.9
Right rectus	464	22.14
Midline	110	5.36
Total	2,100	

TABLE VI

ANESTHESIA

	No. of Operations	Per Cent
Spinal	1,930	91.8
Gas-oxygen-ether	170	8.2
Total	2,100	

TABLE VII

MORTALITY STATISTICS

Total patients	2,100
Total deaths	10
Mortality per cent	0.47

Classification	Operations	Per Cent Operations	Deaths	Mortality Percentage
Acute catarrhal	1,157	55.0	0	0
Acute suppurative	567	27.0	2	0.35
Ruptured with peritonitis	54	2.5	7	12.9
Ruptured with abscess	36	1.7	0	0
Chronic or interval	286	13.6	1	0.34

Table V shows the type of incision used. In women, the midline or right rectus incision is used so that the pelvic organs may be more easily explored. In men and children, in whom the diagnosis seems to be uncomplicated appendicitis, we very generally use a transverse incision, placed at about the level of the anterior superior spine, which divides the external oblique fascia, the internal oblique muscle, and the peritoneum transversely. This incision is easily enlarged if desirable by cutting the rectus sheath and retracting the rectus muscle toward the midline. It avoids the nerves; gives an excellent

and adequate exposure for the purpose intended; is ideal if drainage is required; and in our experience is not followed by muscular weakness or hernia.

TABLE VIII

MORTALITY STATISTICS

Age	Number in Series	Number of Deaths
20–30	1,356	6
30–40	367	2
50–60	20	2
Incisions:		
McBurney	397	4
Transverse	1,129	3
Right rectus	464	3
Status:		
Enlisted men	1,085	6
C. C. C.	349	1
V. B.	149	3
Anesthesia:		
Spinal	1,930	9
Gas-oxygen-ether	170	1

TABLE IX

MORTALITY RATES IN SERIES OF CASES OF ACUTE APPENDICITIS WITH LOCAL PERITONITIS REPORTED IN LITERATURE (SCHULLINGER[1])

Year of Publication	Author	Place	Number of Cases	Period Studied	Mortality Percentage
1925	Adams	London Hospital	467	1919–1923	6.2
1925	Love	St. Thomas' Hosp.	271	1919–1923	5.2
1927	Colp	Mt. Sinai Hosp., N. Y.	975	1916–1926	3.1
1933	Walker	Boston City Hospital	265	1927–1930	1.5
1933	Seelye	Memorial Hospital, Worcester, Mass.	287	1929–1932	1.4
1934	Bower	Philadelphia Hospitals	3,317	1928–1932	2.50
1934	Garlock	New York Hospital II Division	350	1928–July 1932	0.57
1936	Schullinger	Presbyterian Hospital New York	630	1916–1933	1.9
		Total cases	6,562	Average mortality rate	2.8
Cases covered by this report at Station Hospital, Ft. Sam Houston, Texas			567	1931–1936	.35

Table VI shows that we very generally use spinal anesthesia. This seems to us to be decidedly the anesthetic of choice and we believe has a decided

influence on our mortality rates. With this anesthetic, handling of the intestines, packs, and retraction are reduced to the minimum. We have had no ill effects following its use in this series.

TABLE X

TOTAL MORTALITY RATES IN SERIES OF CASES OF ACUTE APPENDICITIS AND ASSOCIATED LESIONS REPORTED IN THE LITERATURE (SCHULLINGER[1] AND MCKENNA[2])

Year of Publication	Author	Place	Number of Cases	Period Studied	Mortality Percentage
1923	Lower and Jones	Cleveland	2,067	Not stated	3.1
1924	Deaver and Magoun	Lankenau Hosp., Philadelphia	5,488	1900–1920	5.0
1925	Adams	London Hosp.	1,677	1919–1923	5.8
1925	Love	St. Thomas' Hosp.	901	1919–1923	8.4
1927	Colp	Mt. Sinai Hosp., New York	2,841	1916–1926	5.2
1928	Weeden	New York Hosp.	1,588	1914–1927	4.9
1931	Miller	Touro Infirmary and Charity Hosp., New Orleans	2,415	1924–1929	9.9
1931	McDonald	St. Mary's and St. Luke's Hospitals, Duluth, Minn.	1,574	1925–1930	4.5
1932	Boland	Atlanta hospitals	4,270	1927–1932	4.4
1932	Raynor	Manchester Royal Infirmary	1,877	1928–1931	5.0
1932	Colt and Morrison	Aberdeen Royal Infirmary	1,349	1911–1930	5.5
1933	Bauer	General Hosp., Malmo, Sweden	5,208	1903–1930	3.3
1933	Walker	Boston City Hosp.	2,106	1927–1930	5.8
1934	Bower	Philadelphia hospitals	14,904	1928–1932	4.79
1934	Nuttall	Liverpool Royal Infirmary	551	Not stated	2.5
1934	Garlock	New York Hosp., II Division	1,188	1921–July 1932	4.7
1934	Keyes	Barnes and St. Louis Children's hospitals	1,099	1915–1932	5.0
1934	Quain	Bismarck, N. D.	1,000	Sept. 1927 to Oct. 1932	3.8
1936	Schullinger[1]	Presbyterian Hosp., New York	2,653	1916–1933	5.08
1936	McKenna[2]	St. Joseph's Hosp., Chicago	3,187	1922–1935	2.48
		Total cases	57,943	Average mortality rate	5.0
Cases covered by this report at Station Hosp., Ft. Sam Houston, Texas			2,100	1931–1936	0.47

Table VII is a tabulation of our mortality statistics. Autopsies were performed upon the ten patients who died. Death in one patient, after an interval appendicectomy, occurred on the fifth postoperative day and came without warning while the patient was reading. Autopsy showed a pulmonary embolus. The abdomen was clean. In the other nine patients death resulted from a spreading peritonitis; two showing a Streptococcic infection of all serous cavities. Table VIII is a further analysis of our mortality statistics. In Tables IX and X comparative mortality statistics are noted. Table IX, acute appendicitis with local peritonitis, corresponds with our acute suppurative classification. These figures are taken mainly from Schullinger[1] and McKenna.[2]

In acute appendicitis, we believe in operating when we make a diagnosis of appendicitis. Our belief in this covers late as well as early cases. Together with all surgeons we have operated upon many patients with the fulminating type of the disease and removed gangrenous appendices, almost ready to rupture, a few hours after the onset of symptoms. Frequently, the symptoms and physical signs in these patients have been mild and might easily lead the patient and surgeon to procrastinate. We cannot determine the type of appendiceal involvement by the symptoms and physical signs and we believe, therefore, that many lives may be saved by operating at the earliest possible moment after the diagnosis of appendicitis is made.

In our practice we bury the stump after carbolization or cauterization. We employ drainage only in cases of ruptured appendix with abscess formation or with peritonitis. Small, soft cigarette or folded rubber tissue drains are used. In the cases without abscess formation we believe drainage, in most instances, to be of doubtful value. We have not used serum therapy in this series. Postoperatively, we avoid dehydration by hypodermoclysis or intravenous injection of salt solution. We use the Bartlett tube, or some modification of it, when indicated and believe it to be a life saving measure.

SUMMARY.—(1) An analysis is presented of 2,100 operations for appendicitis, performed between January, 1931, and October, 1936, with ten deaths, a mortality of 0.47 per cent.

(2) The average mortality for 58,000 cases in civil hospitals has been 5 per cent.

CONCLUSIONS

In our opinion, the lower rate in this series is due to early admission to the hospital, with prompt operation.

We believe that spinal anesthesia contributes to a lower mortality rate.

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VOLVULUS OF THE CECUM AND ASCENDING COLON

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TORSION or volvulus of the cecum and ascending colon is an infrequent and rare cause of intestinal obstruction. In 1841 Rokitansky[21] made the first report of a case of this type. The earliest, thorough consideration of this condition was published by Von Zoege Manteuffel,[27] in 1898. That this condition is rare may be ascertained from the report of Sweet[25] who reviewed the cases of intestinal obstruction admitted to the Massachusetts General Hospital from the period of 1873–1930, not including those due to strangulated external herniae. Of the 520 cases thus studied, only six, or 1.5 per cent, were due to volvulus of the cecocolon. To these the author adds another case, making the incidence seven during a period of 57 years. However, foreign authors, as Gatellier, Moutier and Porcher,[8] and DuRoux,[6] state that the condition is more frequent where people subsist on coarse vegetable diets, as in Russia, Finland, Poland, and Scandinavia. Moreau[16] claimed that volvulus occurred more frequently among Nordic people.

The disease is most common in the third and fourth decades of life, and the sex ratio is approximately three males to one female.[22] Volvulus of the cecocolon occurs only in the presence of a defect in development, namely, a congenitally long mesentery of the cecum, produced by an abnormal rotation of the cecum from left to right.[5] In addition to an abnormally long mesentery, the production of volvulus requires a fixed point about which the intestine can rotate. This point may be the mesentery of the small intestine, or a congenital or inflammatory band resulting from a previous operation. The first case herewith reported had a chronic adhesive appendicitis with its tip fixed to the posterior parietes by many firm adhesions. As a fixed point, this was the contributing cause of the obstruction.

Obviously, the occurrence of volvulus in a "cecum mobile" is dependent upon the length of mesentery upon which the cecum hangs. In fact, Chalfant[3] estimated that there is marked mobility of the right colon in about 20 per cent of persons of all ages. The greater relative frequency of volvulus in males may be due to the fact that males are more exposed to violent muscular effort. However, some cases cannot be explained on such a basis, since they occur during sleep. Overeating and dietary indiscretion, especially when followed by exercise, also predispose to an attack of volvulus. Sudden movements as running, jumping, and lifting a heavy weight may precipitate an attack. Habitual constipation, which tends to produce enteroptosis, may be associated with a congenitally enlarged colon, unrelieved even by operation. The second case reported in this paper clearly demonstrates this concomitant megacolon.

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This patient frequently noted "something move a great deal" in his abdomen, especially when he jumped from a short height in the course of his work. Drastic purgation may cause an attack of volvulus as pointed out by Corner and Sargent.[4] In the early months of pregnancy, when the enlarging uterus pushes a mobile cecum upward, a partial twist may be produced. In addition, the vomiting associated with the pregnant state may be the precipitating factor. Volvulus of the cecum complicating labor has been reported by Basden.[1] Schroder and Brettschneider[24] studied the literature and collected ten cases of volvulus of the right half of the colon complicating pregnancy. A case of postoperative volvulus of the cecum was reported by Nelson.[17]

Volvulus of the cecum has been known to be of three types,[9] namely: (1) Cecal bascule, in which the posterior surface of the cecum looks forward and the axis of rotation is transverse; (2) rotation in an oblique axis, in which the cecum may occupy the umbilical or even the left hypochondriac region; and (3) rotation of the cecum about its long axis.

Embryology.—The primitive alimentary canal appears at the end of the fifth week in the form of a tube, and is subdivided into three parts: The foregut, the midgut, and the hindgut.[19] The blood supply determines these divisions, the foregut being supplied by the celiac axis, the midgut by the superior mesenteric artery, and the hindgut by the inferior mesenteric artery. Physiologically, the same subdivisions prevail: The foregut is digestive in function, the midgut absorptive, and the hindgut excretory. From the foregut, the stomach and duodenum arise down to the bile papilla. The midgut gives origin to the remainder of the small intestine, cecum, ascending colon, and the right half of the transverse colon. The hindgut forms the balance of the colon and rectum.

Among the anomalies of the alimentary tract, there are those due to variations in rotation, descent, and fixation of the intestine.[9] In the embryo of from five to five and one-half weeks, the intestine projects forward into the umbilical cord in the form of a wide V-shaped loop supported by a common dorsal mesentery. At the apex of the loop is the vitelline duct. The limb proximal to it is continuous with the duodenal end of the foregut and that distal with the hindgut. At about the sixth week a bud-like enlargement appears in the limb of the loop distal or caudal to the opening of the vitelline duct, which indicates the future position of the cecum and its appendix. When the embryo has reached a length of about 40 Mm. (tenth week) the coils of intestine rather suddenly return to the abdominal cavity, throwing the cecum over to the right side of the abdominal cavity. This position it retains until about the fourth month after birth.[26] As the large intestine increases in length, the cecum and appendix move farther to the right, still under the liver, and at about the sixth month descend to their normal position in the right iliac fossa. During the process of rotation and descent, the peritoneal surface of the mesocolon, where it comes into contact with the posterior abdominal wall, is normally lost, so that fusion occurs, with fixation of the ascending and descending colon.

Developmental anomalies particularly affect the right half of the colon and small intestine. Rotation may be incomplete, the cecum and ascending colon remaining to the left, while the transverse colon maintains the normal position. Anomalies of rotation are usually coexistent with deficiencies in fixation so that volvulus may result. Likewise, lack of peritoneal fusion may be frequent, resulting in abnormal mobility of the ascending colon. This mobility may be partial or complete. If complete, the whole ascending colon retains its mesentery, and a definite hepatic flexure may be absent. Torsion of the cecum and lower ascending colon may result if in partial fixation the cecum itself remains free. Thus, one can readily understand how an abnormally long mesentery, a mobile cecum, and a precipitating factor such as muscular effort, may lead to torsion of the cecocolon.

Pathology.—The torsion usually occurs in a clockwise manner[18, 29] the explanation by Von Zoege Manteuffel[27] being the peculiar mesenteric attachment of the ileum. Philopwicz[20] found volvulus to occur counter-clockwise in only two out of 24 cases, whereas Weible[29] reported it clockwise in 30 out of 37 cases. Von Zoege Manteuffel's conclusions were based upon 20 collected cases and four of his own. He observed that torsion up to 180° may occur in the axis of the bowel without interfering with its blood supply, but if the twist goes beyond this point, the mesentery which is necessarily present becomes strangulated. Rankin states that a twist of more than one and one-half turns results in strangulation due to occlusion of the vascular elements, gangrene, and occasionally perforation. Observations in the two cases reported in this study do not confirm the above findings. Both cases presented more than two complete turns, and serious occlusive vascular phenomena failed to result. One may conclude that the thoroughness and tightness at the constricting site are deciding factors, rather than the number of turns about a fixed point. Unless permanent fixation bands are present to completely occlude the intestine, frequent detorsion may occur due to the great mobility of the cecum.

Homan[10] mentions the rapid gas formation in the involved portion of intestine, which does not develop elsewhere to the same degree. This observation was made in both my cases, and the enormously distended cecum was out of all proportion to the almost collapsed state of the small intestine proximal to the obstruction. In the usual case of intestinal obstruction, even an obstructive lesion low-down causes a marked dilatation of the proximal gut, demonstrating the fact that mechanisms other than those peculiar to intestinal obstruction are involved here. In volvulus, the loop is well isolated by the twisted ileum and ileocecal valve proximally, and the transition point of cecum into ascending colon distally. In addition, a large amount of fluid intestinal content appears to be absent, another differentiating characteristic from the usual type of intestinal obstruction. In other words, this segment is "closed" as far as the intestinal lumen is concerned, but not with respect to the vascular supply. Cannon[2] and Keith[13] demonstrated in the cat that the receptively relaxed cecum and ascending colon, upon receiving the liquid contents of the

small intestine, undergo activity in the form of an antiperistalsis which retards and churns their contents for a considerable period. This delay favors equally fermentation and the absorption of fluid.[7]

However, other causes for the rapid gaseous distention of the involved loop will be presented and described. The origin of these intestinal gases is by diffusion from the blood stream into the lumen; the decomposition of intestinal contents; and the passage of atmospheric air from the stomach into the small intestine and colon. First, one must consider the mechanism of the diffusion of blood gases to and from the intestinal lumen[15] through the mucosa. Absorption into the blood stream is an important method of eliminating intestinal gases. The rate of absorption varies with the different gases in the intestine. These are: Carbon dioxide, hydrogen sulphide, oxygen, hydrogen, methane, and nitrogen. The rate of diffusion of carbon dioxide is very rapid as compared to the other gases, and there is always an attempt at equilibrium between the gases in the lumen and those in the blood circulating in the intestinal wall. Experiments have been performed ligating the veins of any empty intestinal loop. There results a distention of the intestine by a bloody fluid exudate within a few hours, owing to an increase in capillary pressure and damage caused by a poor supply of oxygen. If the intestinal loop is distended with air before the veins are obstructed, the volume of gas will increase owing to a diffusion into the lumen of carbon dioxide from the blood.

One may, therefore, conclude that in cecocolon volvulus, the constricting mechanism causes a deficient arterial oxygen supply to the involved viscus, together with an accumulation of carbon dioxide in the lumen due to the venous stasis in the intestinal wall. The oxygen will be absorbed and replaced by carbon dioxide and other gases, making an ideal culture medium for the anaërobic organisms that normally are found in the colon. Anaërobic infections very frequently complicate surgery of the colon, and present one of the most virulent types of infection. Ruptured diverticulitis of the sigmoid presents a high mortality because of such contamination. In studying the intestinal flora in health and disease, Kahn[12] noticed that uniformly a majority of the control cases exhibited a nonproteolytic anaërobic spore-bearing group of organisms. The *Clostridium welchii* was the most frequently encountered species in the stools of normal individuals, although usually in smaller numbers than in some of the pathologic series. So virulent are these colonic anaërobes that Weinberg,[30] of the Pasteur Institute, produced two types of serum with anaërobic organisms. This serum is being widely used at the present time in the treatment of peritonitis.

Patients may give a history of abortive attacks of volvulus, prior to admission for operation. Following relief of pain, they evacuate copious, very foul smelling stools. This would confirm the fact that the anaërobic content of the involved closed loop may be the cause of the greatly distended cecum.

Symptoms and Diagnosis.—Volvulus of the cecum presents the clinical

picture of intestinal obstruction, and because of its rarity, is seldom diagnosed except at operation or at autopsy. Pain initiates an acute attack, and, because of the severity, is unlike any abdominal pain previously experienced by the patient. In both of the cases herewith reported, constipation of two or three days' duration preceded this onset. One of the patients had mild attacks for a period of 17 years, while the other was free from such disturbances. Evidently, where there is megacolon and great mobility of the cecocolon, the patient experiences so-called chronic attacks. The pain of volvulus is intermittent and cramp-like in character, caused by the peristaltic and distending phenomena of hollow viscera, as in any other type of acute intestinal obstruction. Like most acute abdominal conditions, a patient's symptoms may be vague and indefinite, simulating the more frequently observed visceral inflammations such as gallbladder disease, as reported by Sarles.[23] Great abdominal distention accompanies the attack, and promptly disappears if the obstruction should be relieved spontaneously. This is followed by the evacuation of a copious foul stool and gas. A large tympanitic mass may be observed in some cases, but the location varies with the amount of mobility of the cecum, as well as its location. Vomiting, of course, is a usual accompaniment, and, inasmuch as the obstruction is at a low point in the intestinal tract, signs of toxemia are delayed. The elevation of blood urea, decrease in plasma chlorides, and increased combining power of the blood for carbon dioxide obtain with regularity only in high intestinal obstructions.[28] Viable bowel has little absorptive power of toxins. Enemata and cathartics are of no avail during an attack. The patient's only relief is obtained by operation, with mechanical detorsion of the volvulus.

Like all congenital abnormalities, volvulus of the cecum may be accompanied by other defects. Case 2 also presented an elevation of the right diaphragm. If more extensive studies and observations were possible, further abnormalities would probably be discovered. Chalfant's[3] case demonstrated a mammalian bicornate uterus in addition to the cecal anomaly.

Treatment.—For those patients who come to operation, one of three procedures should be considered:

(1) Untwisting of the volvulus with the separation of adhesive bands that may be present.
(2) A plastic operation to avoid recurrence.
(3) Resection of the involved colon.

(1) The simplest method, of course, is untwisting the obstructed loop. This method may not be applicable in patients with extreme distention of the colon, because slight trauma may rupture and tear the already thinned-out cecal wall. One may find omental or inflammatory bands completing the obstruction and these should be severed. If, as in Case 2, an adherent appendix helps to precipitate the obstruction, then this must be released and removed. As unsatisfactory as simple mechanical untwisting may seem to

the surgeon for permanent relief, yet if the condition of the patient does not warrant further surgery, one must be content with this procedure.

(2) Cecostomy and suture of the untwisted cecum to the abdominal wall constitutes the operation of choice. The replacement of the greatly distended cecal segment may be facilitated by a radical reduction in its size, following which, fixation bands to the posterior abdominal wall may be more easily visualized, and the exact status of the vascular disturbance ascertained. Since the enormous distention may be caused by anaërobic gas formation, as previously mentioned, and not by fluid content in the lumen, perforation by trocar and cannula is a relatively safe procedure. Through this opening into the collapsed cecum, a Pezzer catheter No. 30 or 32 is inserted, fixed to the margin by catgut, and inverted by a purse-string suture. In closing the abdominal wound, several interrupted sutures include the cecal wall above and below the cecostomy opening, thus fixing the cecum to the abdominal wall in the corrected position. After the resumption of normal bowel evacuations, the cecostomy gradually ceases to function and the Pezzer catheter may be removed. The opening eventually closes without any further surgical procedure.

(3) Resection of the cecum with adjacent involved viscera is reserved only for far advanced cases. Accompanying this late stage volvulus, one usually finds gangrenous areas of the intestinal wall with necrosis. The bowel is so devitalized that contamination of the adjacent peritoneal surfaces is usually present. Even slight handling and manipulation may be disastrous. The only recourse is rapid resection of the gangrenous portion, delivery of the two open loops of gut outside the abdomen with or without tubes. Later, if the patient survives, an attempt may be made to effect continuity and peritonealization. However, this radical procedure results in a mortality of 50 per cent, according to Jacobsen.[11]

Case 1.—No. 17254. H. J., male, age 62, white, steam engineer, was admitted to the Boulevard Hospital July 23, 1935, at 9 P.M., with the chief complaint of pain in the abdomen.

History.—The patient had never suffered from a serious ailment, even in childhood. Never operated upon. Cardiorespiratory and urologic systems were essentially negative. For many years, there had been present reducible, bilateral inguinal herniae. However, for 30 years he had been troubled with symptoms of "stomach ulcer," characterized by the classic picture of hunger-pain, black, tarry stools. Roentgenograms, taken several years ago, confirmed the diagnosis of ulcer. Loss of 30 pounds in weight during the past year, accompanied by moderate fatigue upon exertion.

The pain which caused him to come to the hospital was different from anything previously experienced, and had occurred without any warning signs or symptoms. Early on the morning of admission, the patient had suffered pain in the umbilical region, which had gradually increased in severity. No flatus had been passed since the onset, and an enema upon admission yielded practically nothing. Before entrance, the patient had felt nauseated but did not vomit. Soon after being placed in bed, however, he vomited brownish-green material on two occasions.

Examination.—Reveals an elderly man who appears acutely ill. The abdomen presented a large mass to the right of the umbilicus, the size of a grapefruit, tympanitic to

percussion, and somewhat mobile. Borborygmus was present. No visible peristalsis noted; some tenderness to palpation. Examination of inguinal regions demonstrated complete bilateral inguinal herniae, of large size, which were easily reducible. Blood pressure 170/70. Temperature, 100.4° F.; pulse, 84; respirations, 22. Uranalysis, essentially negative. Leukocytes, 9,400; polymorphonuclears, 72 per cent; lymphocytes, 28 per cent.

Operation.—Anesthesia gas-oxygen-ether. The peritoneal cavity was opened through a right rectus incision over the mass at the level of the umbilicus. A loop of greatly dilated intestines with thinned-out wall presented itself, which was identified as a mobile cecum in the upper abdomen. It was found to be twisted upon itself several turns because of an abnormally long mesentery. The ascending colon was located in the right side of the abdomen, but there seemed to be no point of fixation of the cecum in the right iliac fossa. After untwisting the cecum, the small intestine was seen to enter it in the

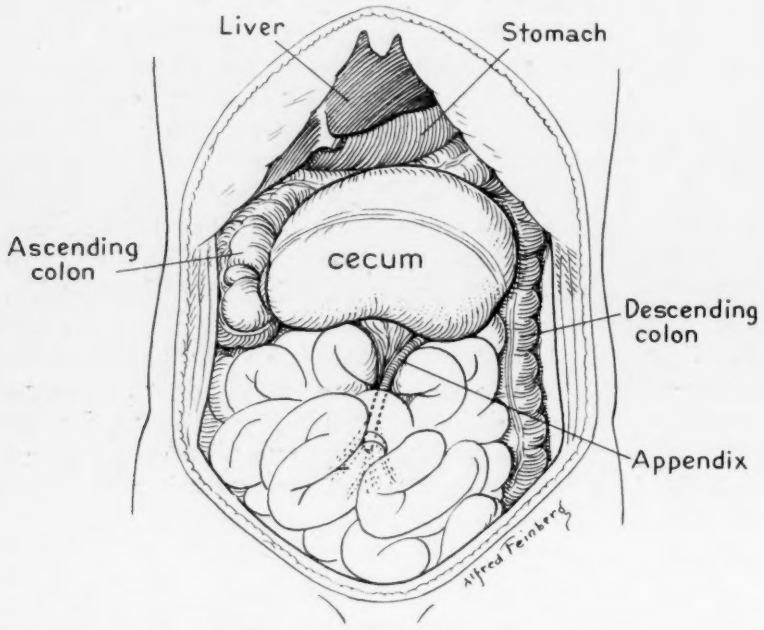

FIG. 1.—Case 1. Drawing representing the findings at operation. A distended mobile cecum was rotated around two fixed points; one being the appendix, bound down at its tip by numerous adhesions, and the other the ascending colon. Note the obstruction of the small intestine by the cord-like appendix.

usual manner. The normal intestinal color immediately returned. The appendix, however, was fibrous, tense, cord-like, and fixed to the posterior parietes by broad bands of adhesions which also contributed to the picture of intestinal obstruction by obstructing the ileum (Fig. 1). The patient's condition did not warrant prolonged surgery. The appendix was removed in the usual manner, after untwisting the volvulus. Since the periappendiceal adhesions were factors in the causation of obstruction, we assumed that opportunity for recurrence would be lessened once the adhesions were removed. The abdominal incision was sutured in layers.

Postoperative Course.—A relatively smooth convalescence ensued, aided by intravenous 5 per cent glucose and saline, together with the Wangensteen suction syphonage apparatus. However, after the sutures were removed on the ninth postoperative day, patient coughed severely, and produced an evisceration through the wound. Secondary suture was immediately undertaken, with through-and-through, interrupted, heavy black

silk, embracing all layers of the abdominal wall. He was discharged from the hospital two weeks later in good condition, with a well healed abdominal wound.

On September 17, 1935, approximately two months subsequent to discharge from the hospital, he was readmitted for abdominal pain, constipation, vomiting, and abdominal distention. The same tympanitic abdominal tumor was present. For about two days prior to this recurrent attack of pain, the patient had been constipated, but the present symptoms began only the night before admission. Suction syphonage drainage with the Levine tube, and intravenous glucose and saline were instituted. All his symptoms disappeared after several copious bowel evacuations had been effected, and he left the hospital at the end of four days.

FIG. 2.—Case 1. A postoperative barium enema study showing the cecum still located in the upper abdomen. Cecopexy had not been performed. There was no megacolon present.

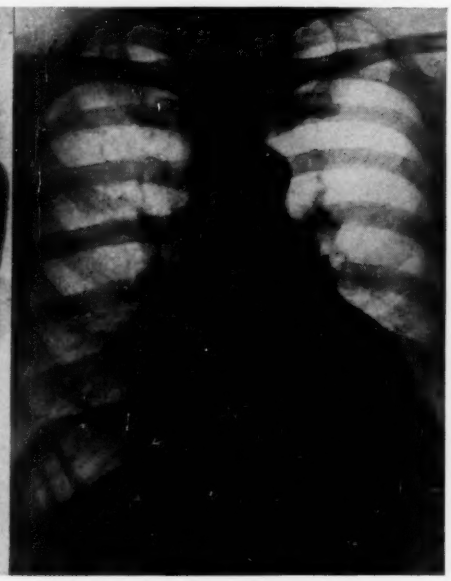

FIG. 3.—Case 1. Roentgenogram showing a raising of the right leaf of the diaphragm, with coils of intestine between it and the liver.

Follow-Up.—Sixteen months later the patient seemed well, and stated that he had no pain. However, he had been troubled with gas, and aften expelled huge quantities subsequent to a stool evacuation. Constipation still troubled him. His wound was well healed, and the abdomen not distended. Roentgenologic studies reveal no great colonic distention. The cecum is moderately dilated and still occupies a position in the upper abdomen, in the median line or to the left (Fig. 2). Megacolon is not present. In addition, his roentgenograms show an elevation of the right diaphragm, and the presence of coils of intestine between it and the right lobe of the liver (Fig. 3).

COMMENT.—This case demonstrates another factor in the production of cecocolon volvulus in addition to an abnormally long mesentery, namely, inflammatory fixation bands around which the cecum may rotate and obstruct the intestinal lumen. In Chalfant's patient an omental band surrounded the intestine at the point of stricture. Freeing of a firm adhesion band in McGowan and Dixon's case[14] apparently cured the patient. The elevation of the right leaf of the diaphragm was discovered incident to a routine roentgenologic study to determine related anomalies.

The occurrence of volvulus was not related to the chronic ulcer illness and happened suddenly, without warning, except for a two to three day interval of constipation. If, at the time of operation, circumstances permitted, this patient would be more secure from future attacks if his cecum were sutured to the abdominal wall.

Case 2.—No. 19817. E. H., white, age 40, laborer, was admitted to the Boulevard Hospital June 16, 1936, with the diagnosis of intestinal obstruction. Temperature, 99.2° F., pulse 80, respirations 20.

History.—During his childhood, patient had measles, scarlet fever, and frequent attacks of tonsillitis. Had never had any symptoms referable to his cardiorespiratory system, except frequent "colds." For the past 17 years, has suffered attacks of abdom-

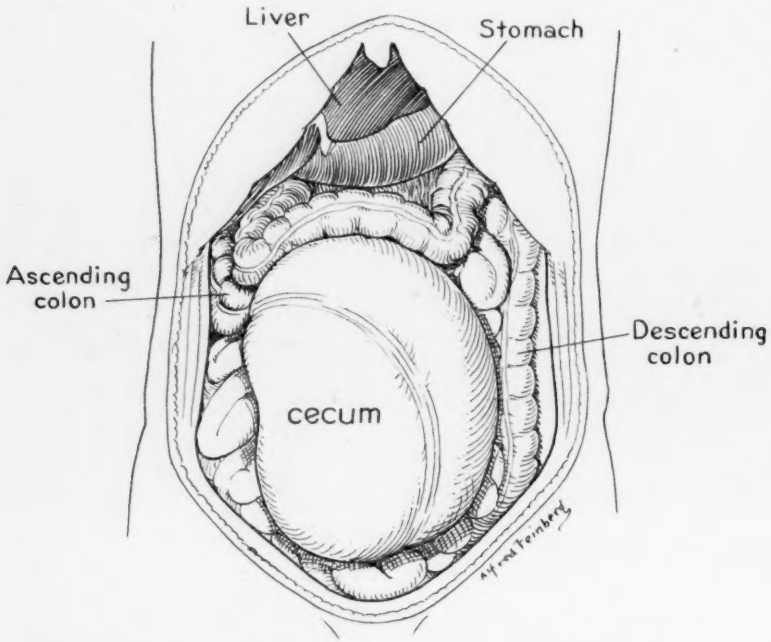

FIG. 4.—Case 2. Drawing representing the findings at operation. An enormously distended cecum, the result of volvulus of the cecocolon, occupied a large part of the abdominal cavity.

inal pain, occurring approximately every six months. These would last from a few hours to as long as one day, coming on at two hour intervals in the beginning, and then increasing in frequency. However, for the past few years, these attacks have returned practically every month and would cause discomfort for as long as a whole week. No nausea or vomiting ever accompanied these episodes, and he always managed to carry on his usual work. He noticed that for two or three days prior to the attacks, he was constipated, and in the interim his stools were dry, hard, and contained mucus with occasional streaks of blood. Relief of pain was obtained by doubling up, crossing his knees, and making very firm pressure on his abdomen. Cathartics and enemata never gave relief. After an attack, he noticed his stools were frothy, contained mucus, were copious in amount, and very foul smelling.

Even though he was termed a laborer, he did no heavy work. If he were to jump a few feet or bend over suddenly, he would feel something move in his abdomen, whereupon he experienced "sour stomach and belching." These incidents were of

momentary duration. He always believed that "his intestines were loose inside of him." Flatus was always evacuated with difficulty, and seemed small in amount.

Present attack began one and one-half weeks before admission with spasms of pain, more frequent than ever before. The pain was of such severity that, for the first time, the patient had cold sweats. For 24 hours prior to operation, his attacks of pain at times recurred every two to four minutes. For three days he was completely constipated, not even passing flatus. On the day preceding admission to the hospital he had taken castor oil, but with no relief.

Physical Examination.—Revealed a middle aged male, not in shock. Blood pressure 150/90. Head, neck, cardiovascular, and respiratory systems essentially negative. Abdomen markedly distended, tympanitic throughout, no masses felt. Uranalysis negative, Blood count, 12,000 leukocytes, 62 per cent neutrophils, 2 per cent eosinophils,

FIG. 5.—Case 2. Postoperative roentgenogram. Barium enema study indicating a large redundant colon, evidently congenital.

FIG. 6.—Case 2. Lateral roentgenogram showing cecum fixed to the abdominal wall following cecopexy. Still greatly extended.

36 per cent lymphocytes. For about ten hours, the patient's intestinal tract was decompressed by Wangensteen's method of suction syphonage with a Levine tube, with only slight relief from pain, and no diminution of the abdominal distention.

Operation.—Under subdural block, using 120 milligrams of neocaine, the peritoneal cavity was entered through a right rectus incision. A small amount of tan colored fluid was encountered. The cecum and part of the ascending colon were enlarged, distended, and thinned-out, to an unbelievably large size (Fig. 4). The obstructive mechanism was a torsion of more than one complete turn produced by a very mobile cecum suspended from the posterior parietes by a long anomalous mesentery. The intestinal wall of the involved loop showed no discoloration, or any signs of permanent vascular impairment. The colon distal to the affected area was somewhat enlarged and distended, while the small intestine itself was almost collapsed.

The involved intestine was untwisted, and a trocar and cannula were introduced, which effected the evacuation of a large quantity of gas, without any accompanying intestinal fluid content. Through this small opening a Pezzer catheter No. 30 was inserted, and fixed to the edges of the opening into the intestine. The cecum itself was fixed to the peritoneal opening by several sutures, and the abdominal wound closed in layers.

Postoperative Course.—The patient was returned to bed in good condition, and the Wangensteen suction syphonage was immediately reapplied, and two and three thousand cubic centimeters of 5 per cent glucose and saline were administered intravenously during each 24 hours. Relief from pain was immediate, and the patient made an uneventful recovery. Before discharge from the hospital, on the thirteenth day postoperative, the Pezzer catheter was removed, as the bowels were functioning normally. The cecal opening closed completely several weeks later.

Follow-Up.—Eight months after discharge from the hospital, the patient stated he has enjoyed excellent health, and for the first time as far back as he could recall, he has had one or two daily bowel movements without cathartics. His wound was closed and well healed and presented no herniation. A moderate amount of distention was still present. This was evidently due to the fact that he has a congenitally enlarged and ptosed colon (Figs. 5 and 6).

COMMENT.—This case illustrates the rapid and extensive gas formation in the closed loop, and the collapsed state of the small intestine. The latter was evidently helped by the Wangensteen decompression, but the pathology in the proximal loops did not resemble that occurring in the usual type of intestinal obstruction, with the accompanying infectious inflammatory process of the visceral wall involving the intestine for a great distance proximal to the point of obstruction. The lack of complete vascular, occlusive phenomena may be accounted for by the fact that the great mobility of the cecocolon, in spite of the torsion, permitted sufficient blood to pass the point of strangulation. The operative procedure of cecopexy and cecostomy selected for this patient is the method of choice. The congenital enlargement and mobility of the remaining colon is well illustrated in the roentgenograms, as well as the fixation of the cecum, still distended, to the anterior abdominal wall.

CONCLUSIONS

(1) Cecocolon volvulus is a form of intestinal obstruction of infrequent occurrence, depending for its mechanism upon a mobile cecum with an abnormally long mesentery.

(2) Abortive attacks of torsion may precede a severe acute attack, and are usually subsequent to periods of constipation.

(3) Rapid and extensive gas formation in the involved loop is probably caused by the action of colonic anaërobes growing in an oxygen deficient region.

(4) Other congenital anomalies frequently accompany this condition, and should be searched for. An elevation of the right diaphragm was discovered in one of the cases herewith reported.

(5) The procedure of choice, if operated upon soon enough, is detorsion, cecostomy, and cecopexy.

(6) Two cases with cecocolon volvulus are herewith reported, whose course and findings closely resemble those previously recorded in the literature.

NOTE.—The author wishes to take this opportunity to express his thanks and appreciation to Dr. Pol N. Coryllos for the many helpful suggestions offered.

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ARGENTAFFINE TUMORS OF THE GASTRO-INTESTINAL TRACT

REPORT OF THREE CASES: ONE WITH DISTANT METASTASES

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THERE have been numerous reports of "carcinoids" or argentaffine tumors of the gastro-intestinal tract. Excellent summaries of this literature have been made by Forbus,[10] Cooke[3] and Raiford.[33] By elaborating on the work of Masson,[25] Lubarsch[21] and Oberndorfer[29] they have definitely classified this neoplasm.

Although it was recognized that this tumor produced distant metastases, as was reported, in 1890, by Ransom,[34] it was still considered benign by some authors, as late as 1934. It is still questioned whether or not the tumor is of epithelial origin and consequently properly classified as a carcinoma.

Thus they present a definite clinical problem although the peculiarities of the tumors may have excited an interest which is beyond their significance. No doubt this tumor has escaped recognition on numerous occasions when appendicectomy has been performed. In relatively few instances is it recognized grossly and the diagnosis is made only after histologic examination.

In the small intestine, it has been encountered most frequently at operation and in the large bowel at autopsy. It has manifested itself clinically by causing intestinal obstruction and intussusception. Occasionally it has made itself known by its metastases, and on several occasions has been discovered in a Meckel's diverticulum. In the appendix it is usually encountered in association with acute or chronic appendicitis. In no case, in the literature, has it been diagnosed preoperatively in any part of the gastro-intestinal tract.

The historic aspects of the argentaffine tumors have been so well presented by Forbus, in 1925, that only a brief résumé is necessary. Lubarsch, in 1888, reported two cases of multiple growths in the ileum and designated them as primary carcinoma although they appeared somewhat atypical. Ransom then, in 1890, described a tumor resembling that of Lubarsch except that although the primary site was in the ileum, it extended through the wall of the intestine and a short distance into the mesentery. There were also nodules in the liver identical in cellular appearance to those in the ileum.

In quick succession there followed several reports of this type of tumor in which there were metastases to regional lymph nodes and to the liver. Several other cases of primary tumor were reported and many of these were spoken of as "endothelial sarcoma." Lubarsch by the use of a silver impregnation method of staining was able to show a definite relationship between the cell nests of the tumor and the crypts of Leiberkühn, which suggested an epi-

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thelial origin. To Lubarsch goes the credit of definitely distinguishing this tumor from the cylindrical cell adenocarcinoma occurring in the gastro-intestinal tract.

Because of certain morphologic resemblances Bunting considered these tumors analogous to the basal cell carcinomata of the skin, which had been described by Krompecher.[19] Oberndorfer, in 1907, first termed these tumors "carcinoid." His observations were made on six cases of multiple tumors of the small intestine, and he differentiated them from carcinoma on the basis that they were generally multiple, that they had no tendency to infiltrate surrounding tissue, that the cells were found in undifferentiated masses, that growth was slow and that they did not metastasize. He then held that they were embryonal malformations.

Huebschmann[16] first made the suggestion, in 1910, that these tumors might possibly arise from chromaffine cells. Oberndorfer then found that their cells stained with chromium salts. Gosset and Masson,[13] in 1914, by studies of the chromaffine cells of the gastro-intestinal tract, discovered the cytoplasmic granules which reduce an ammoniacal solution of silver.

McGlannon and McCleary,[22] Dukes and Lockhart-Mummery[8] had previously found that carcinoid tumors were rich in cells with cytoplasmic granules which gave the characteristic argentaffine reaction. Forbus, Hasegawa[14] and Danisch[6] substantiated the finding of silver reducing cytoplasmic granules in cells in the crypts of Lieberkühn. Forbus by this method of staining was able to point out a third type of tumor which morphologically resembled the carcinoid tumor but followed the clinical course of cylindrical cell adenocarcinoma. The cells of this tumor did not contain granules which reduced silver.

Previously Trappe[44] had stated that carcinoid tumors arose from pancreatic rests in the intestinal tract and Saltykow,[36] in 1912, agreed with Toenniessen that the carcinoids were derived from rests composed entirely of cells like those of the islets of Langerhans.

At the present time it is generally conceded that "carcinoid" or "argentaffine" tumors arise from the Kultschitsky cells found in the base of the crypts of Leiberkühn. This theory is adhered to by many later authors, among them Gáspár,[12] who showed excellent evidence by means of serial sections that this tumor arises from the cells in the crypts of Leiberkühn and that the cells of both the primary tumor and its metastases contain silver reducing granules in their basal portions as do the Kultschitsky cells of the intestinal epithelium. On this basis he concluded that this tumor should be classified as carcinoma. Cooke, Raiford and Humphreys[17] also used these histologic methods and were able to demonstrate silver reducing granules in cells of both the primary tumor and its metastases.

CASE REPORTS

Case 1.—A female, age 18, white, was admitted to the Surgical Service of the Vanderbilt University Hospital complaining of pain and tenderness in the right lower quadrant of the abdomen of 20 hours' duration; nausea and vomiting appeared after

the onset of pain. She had had no previous similar illness. There were no genito-urinary symptoms and no diarrhea.

Physical Examination.—The patient was a pale, rather poorly nourished girl who appeared to be very ill. Temperature, 100.2° F.; white blood cells, 9,300. Uranalysis was negative. The salient physical findings were confined to the abdomen. On palpation there was tenderness over the entire right side, more marked in the right lower quadrant. There was mild muscular rigidity over the area of tenderness.

A diagnosis of acute appendicitis was made and the appendix was removed through a right rectus incision. The mesenteric lymph nodes were not remarkable at time of operation.

Pathologic Examination.—Gross: The appendix was 7 cm. in length. The proximal two-thirds were rather pale but the tip was bulbous and red, the blood vessels were engorged. On opening the appendix the lumen was found to be patent and filled with mucopurulent material. The mucosa was somewhat hemorrhagic. There was no evidence of perforation.

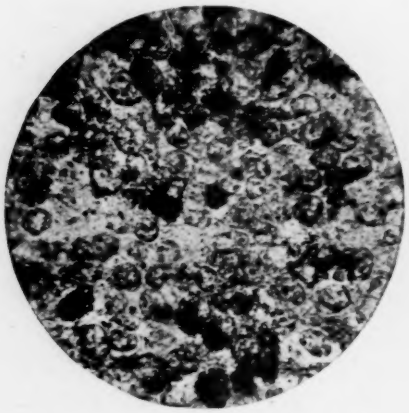

FIG. 1.—Case 1. Photomicrograph of a tumor cell nest showing the silver reducing granules of the tumor cells (oil immersion).

FIG. 2.—Case 2. Photomicrograph showing typical arrangement of cell groups with invasion of the musculature (high power).

Microscopic.—The tip of the appendix showed the normal architecture to have been obliterated by cell nests and strands, the picture being typical of the argentaffine tumor. In addition the walls of the organ were infiltrated with polymorphonuclear leukocytes. Sections through the proximal two-thirds showed it to be essentially normal. The tumor cells were found to reduce silver (Fig. 1).

Follow-Up.—The patient reported herself well nine years after operation.

Case 2.—A female, age 18, white, was seen 21 hours after onset of generalized abdominal pain. The pain became localized in the right lower quadrant ten hours after onset. At this time she became nauseated and vomited several times. There were no urinary symptoms, no diarrhea or dysmenorrhea. One year previously she had a similar attack which lasted for two days and which was not so severe. The remainder of the past history was not remarkable.

Physical Examination.—The patient was a well developed and well nourished young white girl who appeared to be quite ill and in much pain. Temperature, 100.8° F.; white blood cells, 32,000. Uranalysis was negative. The only physical findings of importance were confined to the abdomen, which was noted to move very poorly on respiration. There was almost board-like rigidity of the abdominal muscles and marked tenderness over the entire right lower quadrant.

The diagnosis of acute appendicitis was made and the appendix was removed through a right rectus incision. The mesenteric lymph nodes were palpable but were very small and soft.

Pathologic Examination.—Gross: The appendix was 5.5 cm. in length. It was markedly swollen, reddened and covered with a shaggy fibrinous exudate. The lumen, although patent, was filled with purulent material. The walls were much thicker than normal, particularly in the distal third, and on section they gave a "gristly" feel as the knife passed through them.

Microscopic.—Sections through the distal third showed the typical appearance of the argentaffine (Fig. 2) tumor, while sections through the proximal two-thirds showed no evidence of the tumor. In addition, the walls were densely infiltrated with polymorphonuclear leukocytes. The tumor cells reduced silver.

Follow-Up.—On two occasions this patient has returned to the hospital with symptoms of partial intestinal obstruction which disappeared with conservative treatment. She was well five months after operation.

FIG. 3.—Case 3. Photomicrograph of subserous tumor of the cecum, showing invasion of the musculature (high power).

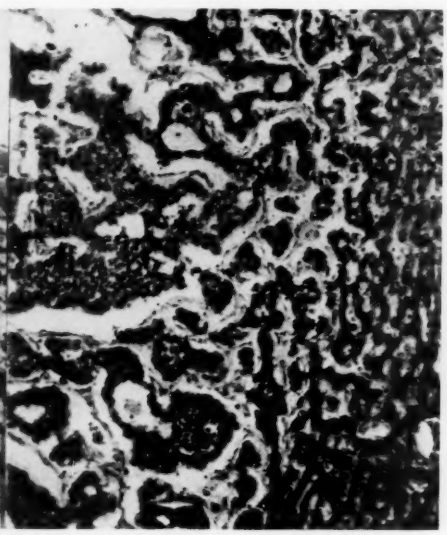

FIG. 4.—Case 2. Photomicrograph of a metastasis to the liver (high power).

Case 3.—A male, age 55, colored, had had numerous admissions to the hospital. He had been found to have syphilitic aortitis with aneurysm of the aortic arch, tabes dorsalis and perforating ulcers of the feet. Death was presumably due to syphilis. There was no history referable to the gastro-intestinal tract which would lead one to suspect the presence of a tumor of the cecum. At autopsy in addition to the aortitis and pulmonary congestion there were two tumors found in the cecum. One was an ulcerated firm polypoid mass measuring 5.6x6 cm. The second was a movable subserous mass approximately the same size as the first tumor (Fig. 3). On section they were both yellowish-white in color. There were several small shrunken areas noted in the liver which had the same yellowish-white color as the tumors of the cecum.

Microscopic.—Both tumors were found to be identical in structure, and were typical of the argentaffine tumor. Sections of the metastases in the liver showed the same type of tumor as was found in the cecum (Fig. 4). Cells of both tumors of the cecum were found to reduce an ammoniacal solution of silver as did the cells of the metastases in the liver.

Pathology.—Humphreys found, from a study of the literature, of all reported cases of argentaffine tumors of the gastro-intestinal tract, with exception of the appendix, that 30 per cent were multiple as opposed to the usual single cylindrical cell carcinoma. Discovery of one of these tumors at operation should lead to a search for others.

They are most likely to occur as nodules in the submucosa and if pedunculated, ulceration may be present. They are usually small in size but may attain the size of any other malignant neoplasm of the bowel. They have on occasion been mistaken for ordinary adenocarcinoma since there is so little difference in gross appearance. They have occasionally been encountered as "napkin-ring" tumors constricting the lumen of the intestine. In consistency, they are usually rubbery rather than being hard. The color on cut section is usually a yellowish-white but some have been described as white or gray.

Microscopically these tumors are composed of round or polygonal cells. The nuclei are vesicular and contain a large amount of chromatin. The cytoplasm is pale and its outline is indefinite.

The cells are usually clumped in nests or strands with an outer rim of cells whose nuclei are peculiarly hyperchromatic and, seen in section, they are drawn away from the dense stroma. They may form in groups about what appears to be a lumen. Some of the cell strands extend into the muscle layers.

The stroma of the argentaffine tumor is usually very dense and places the cell groups in "splendid isolation." Mitotic figures are scarce.

Arising supposedly as it does from the Kultschitsky cell of the intestinal epithelium, most of the cells contain granules which reduce silver. Not all the cells contain granules, and these are termed "indifferent." Sections of a normal appendix and cylindrical cell adenocarcinoma will, if stained with silver, usually show an occasional cell containing granules. Sections of primary argentaffine tumors and their metastases, stained with silver, contain large numbers of cells with the characteristic granules.

These tumors in the appendix are usually located at the tip, sometimes forming a bulb-like mass. They rarely extend beyond the proximal two-thirds of the organ. The histologic picture in the appendix is exactly as in other parts of the intestine except that in most cases there is an inflammatory process present.

In the appendix the tumor is not always apparent on gross examination and the diagnosis is often made only after study of several sections. Norment[28] states that, in his series, only 34 per cent of the appendices containing the tumors were enlarged at the site of the neoplasm. However, cases have been reported in which the bulbous tip of the organ has become so large that it could be palpated through the abdominal wall.

COMMENT.—*Incidence and Malignancy:* The literature contains a large number of reports of isolated cases of carcinoid of the appendix and an occasional report of a series of cases. Many authors fail to make any dis-

tinction between cylindrical cell adenocarcinoma and the spheroidal cell argentaffinoma. Others make careful distinction but do not consider the silver-reducing tumor malignant.

The largest series reported is by Norment, who found 67 carcinomata in 45,000 appendices removed at operation. Two of these he designates as the columnar cell type and the remaining 65 as the spheroidal cell argentaffinoma.

Smith,[39] in his series, found 21 carcinoids in 7,865 appendices removed at operation.

According to St. George,[42] there was no case of carcinoid encountered in Bellevue Hospital prior to 1916, and since that time carcinoids of the appendix were found only twice in 18,700 autopsies. Also at Bellevue Hospital in a series of 9,108 appendicectomies the tumor was found only seven times.

In the Vanderbilt University Hospital, the two cases cited herewith were the only argentaffine tumors found in 2,179 appendicectomies. The single case of multiple tumors of the large bowel is the only case in 1,744 autopsies.

These tumors are reported to arise from all parts of the gastro-intestinal tract except the esophagus, duodenum, and rectum. They are of course encountered more frequently in the appendix than elsewhere. Of all the carcinoids of the appendix which have been reported, only five have extended beyond the organ itself. The extent of metastases varied from extension to the mesentery only, to widespread metastases in the mesentery, omentum, and in one case in the pleura.

Humphreys, in 1933, brought the total number of argentaffine tumors of the small intestine to 152. Since that time there have been seven more reported. One each by Christopher[2] and Jones,[18] both of which were located in the ileum and had not metastasized. One by Price[32] was found in a Meckel's diverticulum and had not metastasized. Two by Lee and Taylor,[20] both of which were in the ileum and both of which had metastasized to the regional lymph nodes. One by Warren and Gates[46] and one by Wood[48]; both of these tumors were encountered in the ileum and had metastasized to the regional nodes.

With these seven additional cases the total now reported is 159 and of this number 36 have metastasized (Table I), representing 22.5 per cent of the series of tumors of the small intestine. This figure may be compared with that obtained by Craig[5] who studied a series of adenocarcinomata of the small intestine and found that 36 per cent had metastasized at time of operation.

With the present case there are now nine reported tumors of the large bowel, three of which had metastasized. In the instances reported by Raiford, one had metastasized to the regional nodes and the other to regional nodes, liver and lungs. Although the series is small, it is of interest to compare it with the figures of Hayes,[15] who found in a study of a large series of adenocarcinomata of the large bowel that 37 per cent had metastasized at time of operation.

Prognosis and Treatment.—From the foregoing statistics it is evident that carcinoid or argentaffine tumor is not a harmless lesion. It is true that many

TABLE I

SYNOPSIS OF MALIGNANT CARCINOIDS COLLECTED FROM THE LITERATURE

Author	Year	Primary Site of Tumor	Site of Metastases	Age	Race	Sex
Ransom	1890	Small bowel	Liver			
Versé	1908	Small bowel	Regional lymph nodes			
Enstratoff	1911	Small bowel	Liver			
Saltykow	1912	Small bowel	Regional lymph nodes			
Dietrich	1913	Ileum	Liver	62	W.	F.
Schopper	1913	Ileum	Liver and regional nodes	54	W.	M.
Engel	1920	Small bowel	Regional lymph nodes			
Bakke	1921	Small bowel	Regional lymph nodes			
Schnebel	1923	Ileum	Liver	50	W.	M.
Dukes and Lockhart-Mummery	1926	Ileum	Peritoneum, liver, regional nodes	76	W.	F.
Stewart and Taylor	1926	Appendix	Pelvis	31	W.	F.
Decker	1928	Small bowel	Regional lymph nodes			
Brocher	1928	Small bowel	Liver	28	W.	F.
Oberndorfer	1929	Appendix	Regional lymph nodes	28	W.	F.
Oberndorfer	1929	Ileum	Regional lymph nodes	52	W.	F.
Oberndorfer	1929	Ileum	Regional lymph nodes. Mesentery	81	W.	F.
Oberndorfer	1929	Ileum	Regional lymph nodes. Mesentery	41	W.	F.
Oberndorfer	1929	Ileum	Regional lymph nodes	48	W.	F.
Pack and Davis	1930	Ileum	Regional lymph nodes	73	W.	M.
Gáspár	1930	Jejunum	Regional nodes and liver	74	W.	F.
Philips and Isaac	1930	Appendix	Ext. to omentum			
Knoflach	1930	Appendix	Ext. to mesentery	64	W.	M.
Ritchie	1930	Ileum	Mesentery and liver			
Marangos	1931	Ileum	Regional nodes and liver	68	W.	F.
Cooke	1931	Ileum	Regional lymph nodes and liver	67	W.	M.
Cooke	1931	Ileum	Regional lymph nodes and liver	65	W.	F.
Cooke	1931	Ileum and jejunum	Regional lymph nodes and liver	60	W.	M.
Scholte	1932	Ileum	Mesentery and regional lymph nodes	40	W.	M.
Mörl	1932	Appendix	Mesentery, pleura, omentum	49	W.	M.
Mörl	1932	Ileum	Regional lymph nodes	26	W.	M.
Mörl	1932	Ileum	Regional lymph nodes	59	W.	M.
Meeker	1932	Small intestine	Regional lymph nodes	61		
Raiford	1933	Stomach	Regional lymph nodes and liver	55	W.	M.
Raiford	1933	Ileum	Regional lymph nodes and peritoneum	45	W.	F.
Raiford	1933	Ileum	Regional lymph nodes and liver	57	W.	M.
Raiford	1933	Appendix	Ext. to cecum and ileum	16	W.	F.

Author	Year	Primary Site of Tumor	Site of Metastases	Age	Race	Sex
Raiford.....	1933	Sigmoid	Regional lymph nodes, liver, lungs	53	C.	M.
Raiford.....	1933	Cecum	Regional lymph nodes	46	W.	F.
Humphreys.....	1934	Ileum	Regional lymph nodes	60	W.	M.
Humphreys.....	1934	Ileum	Regional lymph nodes	60	W.	M.
Humphreys.....	1934	Ileum	Regional lymph nodes	47	C.	M.
Lee and Taylor....	1934	Ileum	Regional lymph nodes	51	W.	F.
Lee and Taylor....	1934	Ileum	Regional lymph nodes	53	W.	F.
Warren and Gates.	1934	Ileum	Regional lymph nodes	53	W.	F.
Ward.....	1936	Ileum	Regional lymph nodes	62	W.	F.

of the tumors were unsuspected and were found at autopsy yet many caused definite symptoms. It is a fact that none of these tumors have been diagnosed preoperatively, but it is of extreme importance that they be recognized when once encountered as they offer a much better prognosis than does adenocarcinoma. The tumor appears to grow slowly and to metastasize late. If metastases are not present at time of operation prognosis is good, and favorable results have been obtained with removal of the tumor and the regional nodes containing metastases. Few tumors of the appendix have metastasized in spite of their frequency. It is possible, however, that the presence of these tumors in the appendix leads to an inflammatory process which brings about their earlier recognition.

All "carcinoids" must be considered slow growing malignant tumors.

As in other malignancies of the gastro-intestinal tract, surgical intervention is the only means of treatment. The effect of roentgenotherapy on the growth of these tumors has not yet been determined.

SUMMARY

(1) A brief résumé of the theories concerning the argentaffine tumors has been presented.

(2) Two cases of argentaffine tumor of the appendix have been presented, as well as one case of a multicentric argentaffine tumor of the cecum with metastases to the liver.

(3) This tumor is a carcinoma arising from the Kultschitsky cell of the intestinal epithelium.

(4) The pathology of these tumors has been briefly reviewed.

(5) The reported cases in the literature have been collected, and 22.5 per cent of tumors of the small intestine were found to have metastasized. Of the nine cases of the large bowel, three had metastasized.

(6) All "carcinoids" are slow growing but malignant tumors. A good prognosis is presented after surgical intervention, even when metastases to the regional nodes have occurred.

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THE MECHANISM OF SPASTIC VASCULAR DISEASE AND ITS TREATMENT *

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BY SPASTIC vascular disease is meant the pathologic state of blood vessels whereby they undergo abnormal contraction on exposure to cold or on emotional excitement. In mild cases there is no pathology demonstrable histologically in the vessels or tissues. In the more severe cases, presumably as a result of the disease process or of associated metabolic disturbances, there occurs swelling of the intima in small arteries and arterioles which may progress to actual occlusion (Fig. 1). Trophic disturbances in the tissues other than the blood vessels then result. These consist of atrophy of the skin and sub-

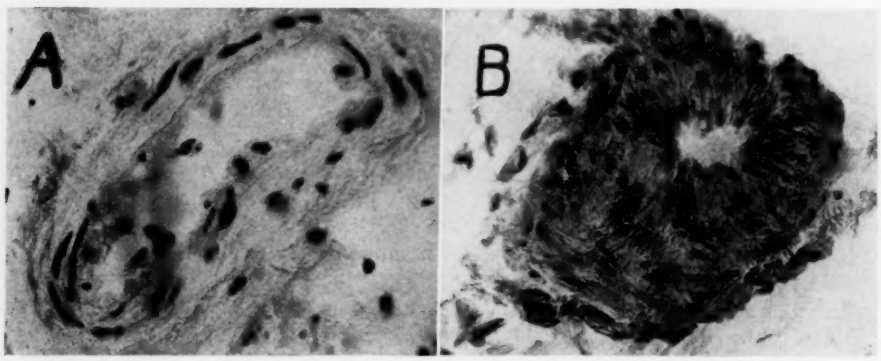

FIG. 1.—(A) Photomicrograph of a blood vessel in the skin, obtained by biopsy from a patient exhibiting Raynaud's syndrome. Note the swelling of the cells of the intima (×600). (B) Photomicrograph of a blood vessel in the tissue from a finger amputated because of gangrene. The patient had advanced Raynaud's disease. Note the thickening and disorganization of the intima, and the thickening of the media. There is marked narrowing of the lumen (×300).

cutaneous tissues, and occasionally of the deeper tissues, including even the bones. Scaly necrosis occurring at the tips of the fingers and toes is a typical lesion, and actual gangrene of the superficial layers, skin and subcutaneous tissue may develop.

The spastic attacks are of variable severity. In some patients there is a bluing of the fingers or toes on exposure to cold with some feeling of numbness. On warming, the involved areas become reddened and remain so for a somewhat longer period than the normal. This reddening is most marked in persons exhibiting some degree of redness of the skin in the normal state. In this group the attacks do not lead to trophic changes even in the vessels them-

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selves. In the more severe cases the spasm is both more pronounced and more prolonged. There is marked cyanosis and pallor during an attack. The degree of cold required to precipitate an attack is less than in the mild cases. Trophic changes, especially necrosis at the tips of the extremities, are frequent. In the most severe cases release from spasm may be incomplete for days. Attacks may occur at ordinary room temperatures, 70° F. or higher. Marked trophic changes are almost invariably present.

The course of the disease is variable. It may remain mild throughout life or it may be present for several years and then disappear entirely. The onset of the disease occurs generally in early life at the time of, or shortly after, puberty. Manifest evidence of the disease may, however, present itself later, at the time of a pregnancy or during a period in which the individual gives evidence of dysfunction of the reproductive system.

Two opposing theories have been presented to explain the mechanism of the spasm of blood vessels. The first of these regards it as an expression of hyperfunction of the centers of the sympathetic nervous system. Chief support for this theory rests in the symmetrical or bilateral nature of the lesions, the paroxysmal character of the attacks and the knowledge that blood vessels have a vasoconstrictor innervation. The second theory regards the etiologic factor as inherent in the walls of the vessels themselves, and not primarily the result of any dysfunction of their innervation.

Hyperfunction of any part of the central nervous system, always difficult to establish or disprove, is often found to be an expression of the elimination of an inhibitory mechanism. This is exemplified, for instance, in spastic disease of somatic musculature. On the basis of experimental evidence, secured from a study made on rabbits, the release from the dorsal root nonmyelinated vasodilators would not be expected to increase appreciably the contraction of the blood vessels, for it has been shown by Bishop, Heinbecker and O'Leary[1] that in these animals reflexly initiated vasodilation over the dorsal roots is not of great magnitude. Continued experience with patients exhibiting the Raynaud phenomena has not yielded any consistent evidence of a generalized hyperfunction of the sympathetic nervous system which if present could reasonably be expected to express itself in hyperactivity of sweat glands or pilomotor muscles. Hyperfunction of the central nervous system doubtlessly accompanies a generalized increase in metabolism in hyperthyroidism. Such an increase is not associated with any tendency to pathologic spasm of peripheral blood vessels. Hyperfunction of the nervous system is present in the early stages of certain virus infections but it does not result in spasm of peripheral blood vessels comparable to that seen in spastic vascular states.

The fact that the lesions are symmetrical is without conclusive significance as to their origin. Indeed, the nervous control of peripheral structures innervated by the autonomic system is primarily unilateral, as it is in the somatic system. The disease process involving it might, therefore, be expected to be frequently primarily unilateral. The impression that the attacks are expressions of spasmodic activity of the central division of the sympathetic

nervous system was gained by observers who failed to recognize the import of the conditions under which the attacks are initiated, *i.e.*, on exposure to cold or on emotional excitement. Under both circumstances the mechanism whereby constriction is produced is a combined reflex and humeral one. Cold produces a reflex excitation of vasoconstrictor impulses to blood vessels and it reflexly produces an increased secretion of epinephrine. Emotional activity expresses itself through motor impulses over the sympathetic nervous system which affect blood vessels, sweat glands and pilomotor musculature as well as causing an increased secretion of epinephrine. The above reactions were not well understood until recently. It should be borne in mind that in a spastic attack these influences will be present, whatever the pathologic condition of the constrictor mechanism.

The above analysis is considered to mitigate against the validity of the conception that hyperfunction of the autonomic nervous system is the primary underlying mechanism. It cannot be said to disprove it. Indeed, reflex activity of the autonomic nervous system is believed by us to be a definite factor in the development of an attack. Normally, on exposure to cold, there is a reflex constriction of blood vessels. While this may be primarily local as is any somatic reflex, there is usually a generalized response more characteristic of autonomic reflexes in general. None of our experimental findings have indicated that the response in persons with spastic vascular disease shows any qualitative difference from the normal. There does appear to be a definite quantitative increase in effect. This is exemplified through study of the effect of changing environmental temperature on the skin temperature in a normal person and in a person afflicted with Raynaud's disease. It is found that the extremities of such persons approach the environmental temperature more than do those of normal persons. Denervated blood vessels show a lessened response to temperature stimuli as compared to innervated ones. Other evidences of reflex influences in spastic vascular disease have been obtained. For instance, in a patient with Raynaud's disease pain developed in all fingers of one hand in the plethysmograph when the air was 21° C., although a thermometer between two fingers, gangrenous at their tips, read 34° C. This occurred within five minutes after cooling started, the air in the room being originally at 32° C., and the initial temperature between the fingers 33.5° C. Reflex constrictions resulting in pain, therefore, occurred before significant cooling. Dipping the elbow of either arm in water at 6° C. resulted in homolateral pain in the fingers within two minutes, but not contralaterally (local reflexes), with no measurable change in temperature of the palm or fingers. This pain persisted for ten minutes, accompanied by cyanosis, with the arm in the air, at 32° C. The patient was put in a cold room at 6° C. with both arms wrapped to the shoulder in three inches of cotton batting. Pains occurred while the temperature between the fingers was still rising (initial temperature 33.5° C., pain occurred at 34° C., and intense pain at 33.8° C.). On coming out of the cold room the pain stopped after four minutes with no detectable change of temperature in the fingers of the

wrapped hand (33.8° C.). The pain was obviously due to reflex spastic constriction and not to changes in temperature of the fingers.

The evidence indicating that there is an etiologic factor inherent in the blood vessel walls, not primarily dependent upon dysfunction of their nerve supply, is twofold: First, is the demonstration that local anesthetization of the nerve supply to a digit during an attack does not relieve the spasm completely, as it should if hyperfunction of the nerves were solely responsible. Partial relief would occur from interruption of the normal impulses responsible for vasomotor tone. Second, is the knowledge that surgical removal of the nerve supply of the limbs which exhibit the Raynaud's syndrome does not prevent the development of attacks in well advanced cases on exposure to cold or during an emotional episode. The explanation offered is that the attacks are now initiated by the action of epinephrine on sensitized blood vessels.

TABLE I

EFFECT OF EXOGENOUS EPINEPHRINE AND INTRAVENOUS GLUCOSE UPON BLOOD VESSELS EXHIBITING THE RAYNAUD SYNDROME

Time	Pulse	Blood Pressure	Condition of Fingers
8:20	100	118/78	No attack
8:21	1 cc. epinephrine subcutaneously.		
8:30	106	134/84	Burning of fingers of both hands
8:35	118	138/86	Bluish discoloration, hands feel cold
8:40	113	144/84	Burning pain
8:42	50 cc. 50% glucose intravenously.		
8:45	115	148/85	Burning pain
9:00	98	148/78	Less pain—fingers feel warmer
9:05	98	135/72	Hands almost as at start
9:15	96	120/68	Hands feel as at start

TABLE II

EFFECT OF INSULIN ADMINISTRATION UPON BLOOD VESSELS EXHIBITING THE RAYNAUD SYNDROME

Time	Blood Sugar	Condition of Fingers
11:00	54 mg.%	Fingers free of spasm
11:05	15 units insulin subcutaneously.	
11:45	46 mg.%	No change in fingers
12:15		Severe pain in all fingers—fingers cold and cyanotic—no sweating
12:30	26 mg.%	Fingers very cyanotic—some cyanosis of whole arms
1:00		No change
2:00	27 mg.%	Fingers still cyanotic and painful
2:30	Meal of eggs, bread, sweetened lemonade.	
2:40		Pain disappearing Cyanosis not so marked
2:50		Fingers free of spasm

That such sensitivity to circulating epinephrine exists, in well established cases of Raynaud's disease exhibiting intact innervation, has been shown by

us in studies on six clinical cases (Table I). With doses of epinephrine ranging from 0.2 to 1.0 cc. (1:1,000 Parke-Davis), average 0.5 cc. it is possible to initiate an attack in such diseased extremities. The spasm frequently involves the part of the extremity quite central to the region showing obvious involvement during an attack initiated by cold. The unaffected extremities under such circumstances showed no unusual changes indicating a definitely increased sensitivity of the involved areas. In well established cases the attacks could be induced in a warm room by giving 10 to 15 units of insulin subcutaneously (Table II). It was possible to relieve an attack with dramatic suddenness by the intravenous administration of 20 per cent glucose. The latter fact, again, definitely suggests that there is no alteration in nervous tone to account for an attack, because the injection of 20 per cent glucose has not been demonstrated to effect vasomotor activity. The amount of fluid injected is not sufficient to explain the opening up of constricted vessels on the basis of increased amount of circulating fluids. It is only possible to explain the effect as a consequence of circulating epinephrine. After denervation of the pupil in cats, sensitivity to epinephrine is increased 20 to 40 fold (Heinbecker[2]). Grant,[3] Hampel,[4] and others, have shown that denervated blood vessels show a definite increased response to exogenous epinephrine.

Nature of the Local, Inherent Etiologic Factor.—The demonstration that vessels subject to abnormal spasm on exposure to cold are sensitized to epinephrine suggests that the local, inherent etiologic factor is similar to that developed in denervated vessels. That it is not due to denervation follows from the fact that cases may recover entirely. Investigations, reported by Heinbecker,[2] have shown that this is to be regarded as a trophic or metabolic change, mild degrees of which may be produced in smooth musculature, generally by thyroid feedings and by hypophysectomy. It is diminished by thyroidectomy, gonadectomy and adrenalectomy. Hyper- or hypodynamic response of such hormonal imbalance is more readily demonstrated in tissue already sensitized by denervation than in normal tissue. Examination of such tissues by routine cytologic methods fails to reveal any definite structural change. There is no alteration in salt content or arrangement as revealed by spectrographic or micro-incineration methods. The fat content likewise is apparently unaltered. The fact that there is no demonstrable cytologic change in the diseased blood vessel is not without parallel when we consider allergic states where violent reactions in smooth musculature occur without any demonstrable pathologic change. Heinbecker has presented evidence, not inconsistent with the interpretation, that in sensitized tissues there is an accumulation of epinephrine or of a substance upon which it acts.

The demonstration that change in smooth musculature, similar to that induced by denervation, may follow from hormonal imbalances, invites the suggestion that this may be the mechanism responsible for initiating a local, inherent etiologic factor in persons exhibiting the Raynaud syndrome. Such an imbalance does not in itself produce Raynaud's disease in animals. One is forced, therefore, to infer a fundamental constitutional or metabolic dis-

order, or tendency to such a disorder, in the blood vessels of certain persons. This, in itself, may lead to spastic disease but it is frequently made manifest only through hormonal imbalances such as occur at the time of puberty, pregnancy, *etc.* Manifestation of the local etiologic factor is usually in the extremity where circumstances of circulation and innervation are most favorable for evidence of impairment.

Discussion.—Spastic vascular disease may be regarded as a constitutional or trophic change in the walls of blood vessels, which makes them respond more than normally to reflexly initiated vasoconstrictor impulses and to circulating epinephrine. The reflexes and the epinephrine secretion being stimulated by exposure to cold or by emotional excitement. Cold itself plays a minor rôle, if any, as a *direct* constrictor agent in the typical spasm.

Treatment of spastic vascular disease should, ideally, be directed toward the prevention or elimination of the local etiologic factor. This, in the present state of our knowledge being an impossibility, treatment must concern itself, primarily, with an elimination of the exciting factors. When such measures are ineffectual, then means of preventing the attack by modification of the innervation and tone of the involved blood vessels are warranted in addition.

Elimination of the exciting factor, cold, can be accomplished by the wearing of proper protection for the hands and feet. This will suffice in the mild cases. If it is possible for the individual to live in a warm climate he may under such circumstances remain free from attacks. Attacks in the emotionally unstable may be lessened by the institution of a proper psychotherapeutic regimen.

When attacks develop on exposure to a temperature of 70° F., surgical measures designed to diminish the tone of the involved vessels and to eliminate them from the influence of constrictor nerve impulses are warranted. Such effects may be accomplished by sympathetic denervation of the involved extremities. Two courses are open: One the institution of preganglionic and the other of postganglionic denervation. Postganglionic denervation is permanent. There can be no question of regeneration, and it will eliminate all possible reflexes by constrictor impulses, but it leads to a sensitization to epinephrine. This, in itself, may result in a constriction of the blood vessels on exposure to cold or on emotional excitement, because under such circumstances epinephrine is secreted. In about one-half the clinical cases operated upon temporary relief only is accomplished and in many instances attacks still occur. The diminution in some cases, brought about by denervation, is only temporary. Experimental investigation of the duration of decreased tone after postganglionic denervation has yielded results which show that such altered tone does not last for more than 10 to 12 months and may be of much shorter duration (Heinbecker). After this time the only benefit to be derived from denervation is the elimination of reflexly instituted constrictor impulses. Preganglionic denervation of the cat's iris sensitizes it to only about 10 to 20 per cent of the degree of sensitization produced by postganglionic denervation (Heinbecker). The duration of the decrease in tone in de-

nervated cat's iris is about one-half that resulting after postganglionic denervation (Heinbecker). If regeneration be prevented by proper technic the reflexly exerted constrictor impulses will be eliminated permanently. It is felt that because of the lessened sensitization to epinephrine resulting from preganglionic denervation it is the procedure of choice. This idea is supported by the fact that clinical results reported after surgical interference in cases in which the lower extremity was affected were more satisfactory than in those involving the upper extremity. The better results in the lower extremity cases are attributed to the fact that the operative procedure generally employed is one in which the preganglionic fibers for the most part are interrupted (White[5]).

The surgical procedure recommended in instances where the upper extremity is involved would be one which would denervate the preganglionic fibers coming from the first, second and third thoracic nerves. An operative procedure recently described by Telford,[6] and by Smithwick,[7] in which they advise the resection of a portion of the second and third thoracic nerves from the spinal ganglion outward for one and one-half inches, and a section of the sympathetic trunk below the third ganglion, may have the disadvantage of incompleteness. By this procedure the preganglionic fibers from the second and third thoracic level, and from levels below this, are eliminated. Preganglionic neurons from the first thoracic level, and above, are not eliminated. The number of fibers derived from these sources in the cat are considerable (Kuntz, Alexander and Furcolo[8]). If it were possible to eliminate the first thoracic nerve the procedure would doubtless be more efficient, but this is not possible because the first thoracic nerve is an important motor nerve to the upper extremity. Under the circumstances it seems advisable to advocate the cutting of the rami communicantes from the first thoracic nerve also. This, of course, adds the complications associated with Horner's syndrome. Operation upon the lower extremity consists in removal of the second and third and sometimes the fourth lumbar ganglia. By this procedure preganglionic fibers to the lower extremity are interrupted. Postganglionic neurons for the lower extremity lie, for the most part, in the fifth lumbar, and first and second sacral ganglia. In this procedure the degree of senitization is minimized. The end-results reported by all operators are quite satisfactory.

CONCLUSIONS

Inasmuch as spastic vascular disease is not primarily dependent upon the dysfunction of innervation but to a local, inherent, trophic etiologic factor, there will always be cases in which the disease process will progress to a point where sensitization to epinephrine, in itself, will be enough to bring about an attack whenever an unusual amount is secreted despite the elimination of other influences. Then too, when the disease is progressive, changes leading to occlusion of vessels always develop. Surgical procedures cannot be expected to greatly improve those cases in which occlusive disease is already present to a marked degree at the time of operation. Future efforts should

be directed to search for the cause of the constitutional derangement apparently present in these cases.

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NEOPLASMS OF THE ABDOMINAL WALL

WITH SPECIAL REFERENCE TO MALIGNANT "IMPLANTATION" TUMORS

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KLOT,[7] in 1921, collected 408 cases of tumors involving the abdominal wall, of which 248 were fibromata, 67 fibrosarcomata, 17 fibromyxomata, 60 sarcomata, one endothelioma, one angioma and one angiosarcoma. Since then an occasional case report has found its way into the literature from time to time. A survey of the Index Medicus shows but few instances of adenocarcinoma present in the abdominal wall unassociated with some type of fistulous communication with, or direct extension from, an abdominal organ harboring carcinoma.

To indicate the relative rarity of malignant tumors of the abdominal wall, Gurlts,[5] out of a total of 16,637 cases of malignant tumors, found only 27 malignant tumors of the abdominal wall, of which there were 13 carcinomata and 14 sarcomata. Dvorak,[4] reviewing the records of 28,013 admissions at the University Hospital of the University of Minnesota, between 1910 and 1923, found only nine cases of abdominal wall tumors, of which number there were only two carcinomata and one sarcoma arising by direct extension.

Vosburgh[17] classifies abdominal tumors as:

(1) Superficial (sebaceous cysts, papillomata and cutaneous moles and lipomata).

(2) Fibromata (hard and soft), the harder arising from the aponeuroses and tendinous insertions, while the softer ones take origin in the subcutaneous tissues and in the fibrous sheaths of vessels and nerves.

(3) Desmoids are fibromata in which the constituent elements have a special arrangement and arise usually in the anterior or lateral abdominal wall, and in about one-half of the cases are associated with the rectus muscle or its sheaths, usually the posterior. Desmoids are seven times more frequently encountered in women than in men. These tumors are usually small although they may grow to large size, are smooth and ovoid, with their long axes parallel to the long axis of the rectus muscle. On section the cut surface is of a glistening white color with fibers interwoven. Microscopically the tumors may be poor or very rich in cellular elements, and are poor in blood supply, which makes them liable to early necrosis.

(4) Carcinoma—Carcinomata of the abdominal wall fall into two groups, namely: (a) Those involving the abdominal wall proper; and (b) those arising from the umbilicus. Primary carcinoma of the abdominal wall proper, while possible, must be extremely rare, since, with the exception of those cases already discussed, no such case has been found by the writer in a re-

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view of the literature. Secondary carcinomata in the abdominal wall occur: (a) By direct extension from an adjacent intra-abdominal organ; (b) through a fistulous communication with a hollow abdominal organ harboring a carcinoma; and (c) by true metastasis from a distant organ or by direct implantation at the time of a previous operation.

Carcinoma of the umbilicus is not a rare phenomenon and may occur either as a primary or as a secondary growth. Squamous carcinoma is the most frequent primary carcinoma of the umbilicus and usually arises from epithelial remnants of the urachus or omphalomesenteric duct. Columnar cell carcinoma of the umbilicus usually indicates a secondary growth from an intra-abdominal organ.

(5) Sarcomata in the majority of cases represent a malignant transformation of preexisting benign tumors, such as a nevus or a fibroma. There are some tumors which start as sarcomata.

(6) Melanosarcoma which is generally a part of a general sarcomatosis; and finally

(7) Endometrioma (not mentioned by Vosburgh[17]), or a transplant to the uterine mucosa during the period of menstruation found in the abdominal wall particularly after operations on the uterus, especially caesarean section.

Since the case herein cited is that of an adenocarcinoma of the abdominal wall occurring 13 years after the removal of an apparently benign ovarian cyst, it might be well to note that as far as the writer was able to ascertain, there are only 14 references in the literature (six collected by Dvorak[4] and eight by Polano[14]) in which the presence of a carcinoma of the abdominal wall, following the removal of a supposedly benign ovarian cyst, did not arise by direct extension from an abdominal organ harboring carcinoma which was adjacent to that portion of the abdominal wall, or in the case of a hollow viscus affected with carcinoma, with some type of fistulous communication.

An unusual case reported by Dvorak, and simulating the one about to be described, was that of a woman, age 69, who 15 years previously had had the uterus, left ovary and tube together with a cyst and two tumors of the uterus removed. Following the operation the abdominal wound became infected so that healing was delayed. The pathologic report of the specimen was unfortunately not stated. For 13 years the patient was apparently well; she then noted a lump in the left lower abdominal quadrant, which, during the next two years, grew to the size of a football, and was accompanied by sharp shooting pains. The tumor extended from a point 5 cm. below and 9 cm. to the left of the umbilicus to a point on the pubic crest 3 cm. to the right of the midline, was slightly tender to palpation and appeared to be imbedded in the musculature of the abdominal wall. The skin was not adherent to the mass. A diagnosis of desmoid of the rectus sheath was made and removal advised. Adenopathy was absent.

The tumor, including a large part of the left rectus muscle and its anterior sheath, was removed. The pathologic report was adenocarcinoma, made up of alveolar glands lined by columnar epithelial cells. Three courses

of deep roentgenotherapy were given, followed later by implantations of radium to a local recurrence. The patient developed a large incisional hernia. She lived about five years after operation, succumbing finally to local and distant metastases to the vertebrae. Postmortem examination revealed two fistulous communications, one with the ileum and the other with the transverse colon. There were no metastases in the peritoneum, nor in the pleural and pericardial cavities. The lymph nodes were also free, but metastases were found in the fourth and fifth lumbar vertebrae. The local recurrence consisted of a mass 5x2 cm., consisting of many atypical and poorly formed alveolar structures lined by tall columnar cells. The findings suggested a papillary cystadenocarcinoma of ovarian origin.

Although there was no proof to substantiate it, the origin of this tumor was believed to be an implantation of a portion of the apparently benign ovarian cyst into the abdominal wall incision at the time of the operation performed 20 years previously.

In 1864, Wagner described a case of a patient who developed three subcutaneous cystic tumors, one below the left breast, one in the right axilla and one in the left flank following frequent tapping of the abdomen for ascites resulting from a large intra-abdominal, benign, papillary, serous cyst of the left ovary. At autopsy the subcutaneous cysts were of identical histologic structure to that found in the affected ovary.

Jaquet[6] (quoted by Dvorak) reported a case of a dermoid of the ovary removed in 1874, and 17 years later the patient developed a malignant tumor, measuring 15 cm. in diameter, in the abdominal wall.

Olshausen[12] reported a case of a patient, 46 years of age, who 21 years previously had a left oöphorectomy performed. Seventeen years later he removed a tumor from the right side of the abdominal wall above the umbilicus. Histologically the character of the tumor was that of a benign papillary cystadenoma of the ovary. Olshausen was of the opinion that this tumor resulted from an implantation in the abdominal wall during the course of the oöphorectomy performed 17 years previously.

This same author also reported a case of a woman, who at the age of 29 had a bilateral oöphorectomy performed for papillary cysts. About 20 years later she noticed a mass in the right side of the abdomen which had progressively increased in size. The tumor was found situated in the abdominal wall and when removed was diagnosed, from its gross appearance, as undoubtedly carcinoma. No histologic report appears in the protocol. Just as in the previous case, Olshausen believed this tumor to have occurred as a result of implantation at the time of the oöphorectomy, since the tumor was present in the scar of the previous operation.

Tauber[16] reports that Schneutgen,[15] up to 1918, was able to collect only eight cases from the literature of benign ovarian tumor implantations in the abdominal wall, and added one case of his own.

Bland-Sutton[1] performed a hysterectomy and bilateral oöphorectomy for what appeared to be benign papillary ovarian cysts. Six years later the patient

noticed a rapidly growing tumor in the right side of the sternum in the second intercostal space, which promptly recurred after removal and eroded the entire manubrium. Histologically this tumor was identical with the primary tumors of the ovaries. At autopsy there was no recurrence in the abdomen.

An interesting case is reported by Tauber of a woman who, in 1919, was explored for ascites, but apparently no tumor found. Two years later with recurrence of ascites, celiotomy revealed bilateral papillary ovarian cysts, with three small cysts on the anterior parietal peritoneum below the umbilicus. These were removed along with both ovaries. Histologically there was no evidence of malignancy. Five years later she returned with a cystic tumor in the anterior abdominal wall around the umbilicus, which proved to be a malignant ovarian cyst. Tauber also reports that Lang[8] removed a pseudomucinous cyst from the left ovary of a patient, age 30, and after two months an adenocarcinoma developed in the scar of the previous celiotomy.

Taking the ten cases collected by Dvorak, including the one he reported, along with the case herewith described, brings the total of cases, in which apparently benign ovarian cysts were followed at varying intervals by benign or malignant tumors of ovarian origin in the abdominal wall, to 11 cases. Of these 11 cases, the abdominal wall tumor was found malignant in seven, and benign in four. The longest interval between the removal of the original tumor and the discovery of the abdominal wall tumor was 21 years, while the shortest interval was two months. In six of the 11 cases, however, the interval was over ten years. While in all of these 11 cases the primary tumor of the ovary was apparently benign, Cullen[3] collected nine cases of malignant abdominal wall tumors following extirpation of malignant ovarian tumors.

In addition to the ten cases discussed by Dvorak, Polano collected seven cases, and added one of his own, of malignant abdominal wall tumors occurring in the scars of previous celiotomies for the removal of apparently benign ovarian cysts. At autopsy, his own case was found to have a carcinoma of the stomach, and Polano believed that this was the primary growth. Unfortunately out of the seven case reports which he collected from the literature, necropsy was obtained in only one (Pfannenstiel[13]), and in this case the autopsy failed to disclose any intra-abdominal evidence of malignancy. The absence of concrete evidence of the existence of an intra-abdominal malignant focus in six out of eight cases led Polano to the conclusion that in spite of the fact that oöphorectomies for apparently benign ovarian cysts antedated the finding of malignant tumors in the abdominal wall, these tumors might have had nothing at all to do with the original ovarian cysts, but might be metastatic tumors developing from some preexisting malignant tumors of other abdominal organs present but overlooked at the time of the original operation, or having developed subsequent to the oöphorectomy.

In order to understand the mysterious circumstances of malignant abdominal tumors following the removal of apparently benign primary ovarian tumors, it might be well to refer to the excellent paper of Mayfield[11] in 1927. From an analysis of 100 cases, Mayfield comes to the conclusion that the

size of the cysts is no indication as to the character of their pathology and that often both benign and malignant features were found present in the same specimen. This same author noted various degrees of malignancy in the same type of tumors, which might explain the variations in the time interval between the removal of the original cyst and the appearance of the abdominal wall tumor. He also looks upon bilateral, papillary ovarian cysts as always suspiciously malignant, even though the microscopic findings may not confirm the suspicion, since it is so easy to overlook a small area of malignancy unless complete serial sections are made and examined of the removed specimen. So that the removal of a cystic tumor of the ovary which to all intents and purposes has been judged benign from microscopic and gross examinations may still have been malignant; and the long interval existing between the removal of the original ovarian tumor and the finding of the malignant abdominal wall neoplasm may be explained on the ground that the grade of malignancy of the original tumor was extremely low.

Instances of abdominal wall implants of other types of benign tumors following some type of operation upon the female generative organs such as fibromyomata and adenomyomata, also designated endometriomata, have been frequently described in the literature (Brewer[2], Cullen[3], Mahle and MacCarty[10], Lochrane[9], and others).

Diagnosis.—To determine whether a tumor is situated in the abdominal wall or beneath it, the patient, lying on her back, is instructed to sit up unaided. In so doing, the abdominal muscles are contracted and should the tumor become invisible and nonpalpable, it is certain that it is not situated in the abdominal wall. Should the tumor, however, still remain palpable and immovable, even though it can no longer be seen, with the patient's muscles contracted, it can be stated that it is situated in the abdominal wall. An intra- or subcutaneous tumor does not change at all during the maneuver. The exact nature of the abdominal wall tumor can only be determined by biopsy.

Treatment.—Benign tumors are treated by extirpation. In dealing with a definitely malignant tumor of this type, treatment becomes a definite surgical problem. Since one can only be reasonably certain of whether a malignant tumor of the abdominal wall is primary or secondary to some intra-abdominal organ, exploratory celiotomy is indicated in all cases to establish the presence or absence of a malignant intra-abdominal tumor, and even then one cannot always with absolute certainty rule out the presence of such a growth. A negative exploration then leaves the operator with the problem of what to do with the abdominal wall tumor. In the event the tumor is a small one, extirpation should be effected and the defect in the abdominal wall repaired wherever possible. With tumors involving a large portion of the abdominal wall, one should proceed cautiously before deciding upon extirpation. One must reason in such cases that a tumor which has grown large enough to involve a large portion of the abdominal wall must already have given rise to metastases. Extirpation then would result in a large incisional hernia with-

out any further compensating advantages over the employment of irradiation. It is the writer's opinion that malignant tumors invading large segments of abdominal wall had best be considered beyond the scope of radical removal, and treated with deep roentgenotherapy or radium.

Case Report.—S. Z., female, age 42, single, presented herself November 28, 1936, complaining of menorrhagia, pain in the pelvis and a burning sensation in the lower abdomen of three months' duration. Her mother had died of cancer, but she did not know the organ involved.

Her menstrual history was entirely normal. Menstruation commenced at the age of 13, was regular every 28 days, lasted three to four days, and was unassociated with any pain. Thirteen years previously she was operated upon for a "cyst of the left ovary" which was considered benign. Unfortunately, no record could be found of the histologic findings of the specimen removed. Since the removal of the ovary she noted a slightly increased growth of hair on the face, a deepening of the voice and diminished libido. Otherwise she felt perfectly well.

Three months previously she noted an increase in the menstrual flow. There was no metrorrhagia, but she complained of a dull, intermittent aching pain deep in the pelvis and a burning sensation in the lower abdomen. There was no loss of weight, no anorexia or symptoms referable to the gasto-intestinal tract. The rest of the history was entirely irrelevant.

Physical Examination revealed a well developed, robust patient. Blood pressure 118/90. Situated in the lower abdomen to the right of the midline, and extending from the symphysis pubis to the level of the umbilicus, there was a firm, hard, irregular mass, neither tender nor movable. The mass could be felt when the patient was asked to sit up from a recumbent position. Directly over it was a long right lower rectus scar of the previous operation. Vaginally one could not make out any relationship between the mass and the uterus which felt perfectly normal.

A scout roentgenogram of the pelvis revealed an indefinite small shadow situated over the sacrum which was thought to be a calcified lymph node. Roentgenologic examination of the genito-urinary tract was negative. A barium enema likewise showed no abnormalities. Uranalysis was negative. Blood count: Hemoglobin, 88 percent; red blood corpuscles, 4,320,000; white blood corpuscles, 5,200; morphonuclears, 55 per cent; lymphocytes, 34 per cent; rods, 7 per cent; monocytes, 4 per cent.

A tentative diagnosis of abdominal tumor not associated with the uterus was made, and exploratory operation advised.

Operation.—December 3, 1936: Under spinal anethesia, a three and one-half inch midsuprapubic incision was made. Upon extending the incision through the subcutaneous fat, it was immediately noted that the tumor involved the abdominal wall and extended from the symphysis pubis up to the level of the umbilicus, involving both sheaths and body of the right rectus muscle. The peritoneum was opened by retracting the tissues to the left and incising through the left rectus muscle and peritoneum. Exploration failed to reveal any involvement of the pelvic or abdominal viscera. With the hand in the peritoneal cavity, the affected portion of the abdominal wall was exposed and found to simulate an extensive, convex, pancake-like tumor of cartilaginous-hard consistency, extending from the symphysis pubis to the umbilicus, and from the linea alba laterally to a line drawn from the crest of the ilium to the midportion of the twelfth rib. It was of a yellowish-white color and the most central part of the growth was of a softer consistency than the peripheral portions. A portion of the tumor was removed for biopsy.

Pathologic Examination.—(Dr. A. A. Eisenberg, Sydenham Hospital.) The specimen measured 3x1.5 cm. The external surface was of a grayish-white color and the consistency of the tissue was firm. On section the tissue was uniformly white.

Sections show numerous carcinomatous areas scattered throughout the entire sections, with many of them arranged in the form of small acini. The cells show numerous mitotic figures and anaplastic changes. Occasionally one sees a group of small acini presenting as adenomata. Between the acini there is a moderate lymphocytic infiltration and a few hemorrhagic areas (Figs. 1 and 2).

Diagnosis.—Adenocarcinoma. Dr. Francis Carter Wood who examined the slide believed that the specimen could very well represent ovarian tissue and noted a group of large cells extremely suggestive of arrhenoblastoma.

Postoperative Course.—Following her discharge from the hospital the patient was placed upon intensive deep roentgenotherapy resulting in considerable shrinkage of the

FIG. 1.—Photomicrograph showing the arrangement of cells, particularly indicating groups of cells suggesting arrangement seen in arrhenoblastoma of the ovary (×125).

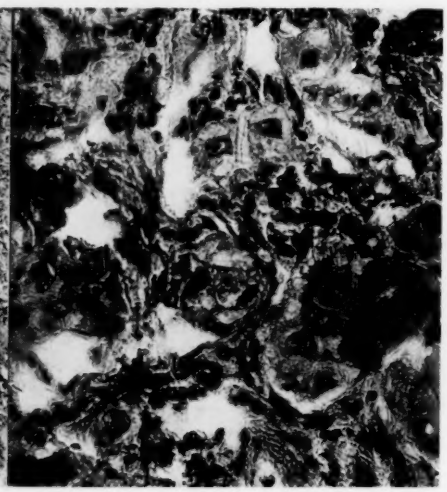

FIG. 2.—Photomicrograph indicating the character of the cells slightly suggestive of cells seen in arrhenoblastoma (×725).

tumor. Yet, in spite of the reduction in size of the original growth, she developed a large hard node in the left groin which is responding to irradiation. Her general condition to date is good.

SUMMARY AND CONCLUSION

Carcinomatous tumors of the abdominal wall unassociated with fistulous communications with, or direct extension from, an abdominal organ harboring carcinoma are extremely rare. A careful review of the literature reveals seven cases including the author's case in which, following the removal of an apparently benign cyst of the ovary, after an interval ranging from two months to 21 years, a carcinomatous tumor occurred in the abdominal wall either in the scar of the original operation or close to it, apparently without any other intra-abdominal involvement (Dvorak, 6; Lazarus, 1). Polano collected seven cases of malignant abdominal wall tumors occurring in the scars of previous celiotomies for the removal of apparently benign ovarian cysts and added one of his own. At postmortem, however, his own case was found to have a carcinoma of the stomach, which the writer believed was the growth responsible for the abdominal wall tumor. Of the seven cases which he col-

lected from the literature, autopsy was performed in only one and this one failed to reveal any evidence of intra-abdominal malignancy. The remaining six cases without postmortem evidence led Polano to the conclusion that one cannot with certainty state that a given intra-abdominal carcinoma, even though histologically resembling the architecture of an ovarian cyst that had previously been removed from the same patient, was secondary to such a cyst, since one might have overlooked a malignant growth in another intra-abdominal viscus which had been present at the time of original operation or had developed subsequent to the oöphorectomy. In view of the fact that, of the ten cases reported by Dvorak and also the one reported by the writer, autopsies were obtained in only three, and in none of these was there found any intra-abdominal pathology other than that occurring in the ovary, it might be justly argued, with Polano, that the failure to confirm by complete autopsy the presence or absence of a malignant growth elsewhere in the body invalidates, to a certain degree, the conclusion that a malignant tumor of a supposedly benign ovarian cyst is the result of an implantation taking place at the time of the original operation. That such a phenomenon is possible, however, has been definitely established by the few autopsies that have been obtained and reported. Furthermore, it is difficult to understand the underlying reason of a malignant abdominal wall tumor occurring after the removal of a benign cystic tumor of the ovary unless we assume the possibility of such a tumor possessing low grade malignant possibilities at the time of the original operation.

Biopsy is the only reliable means of determining the nature of a tumor of the abdominal wall. The prognosis is always bad. Treatment of small tumors consists of thorough abdominal exploration followed by extirpation of the growth and deep roentgenotherapy. In the large tumors extirpation is not advised since removal of large sections of abdominal wall always leads to serious postoperative herniation, without in any way adding to the life expectancy of the patient, which is not offered by the less mutilating use of irradiation therapy.

A case is herewith presented of an extensive adenocarcinoma of the abdominal wall, in the region of the scar of the previous operation, in a young woman who, 13 years previously, had had an oöphorectomy performed for a supposedly benign ovarian cyst. Exploratory celiotomy failed to reveal the presence of any intra-abdominal pathology. The treatment administered in this case was deep roentgenotherapy.

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BLOOD LOSS IN NEUROSURGICAL OPERATIONS

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The purpose of this paper is to call attention to the large volume of blood lost in major neurosurgical operations in contrast to the comparatively moderate amounts lost during operations on the abdominal viscera, the thorax, and the extremities. In another article[1] water balance in neurosurgical patients has been considered. Both communications point out certain aspects of blood loss and water balance in brain operations which must be understood and skillfully handled in order to avoid serious disturbances in the blood and tissue fluids.

Gatch and Little,[2] and also Coller and Maddock,[3] have shown that in the average celiotomy it is unusual for hemorrhage to exceed 200 cc. In their determinations they record no statistics on neurosurgical operations,* and in a search through the literature we have been unable to find any such data. It is, therefore, of interest to point out that in extensive craniotomies a blood loss of from 500 to 1,200 cc. is quite usual, while in unusually vascular tumors hemorrhage in excess of one and one-half liters may occur. Many neurosurgeons, fully conscious of the importance of hemostasis, are unaware of the amount of blood which is removed, so unostentatiously, by the suction apparatus and which is absorbed by the multitude of small pledgets. This was brought out in our early measurements when the surgeon's rough estimate of the amount of blood lost was compared with the figures obtained from the hemoglobin content of the drapes, pledgets, and contents of the suction bottle.

In addition to this excessive loss of blood, we have shown[1] that a patient undergoing an operation for an intracranial tumor may lose up to 1,000 cc. of fluid from his skin and lungs. This also is, at times, in excess of the loss of water vapor which takes place in other surgical operations. In the latter, careful hemostasis is essential to prevent postoperative hematomata and poor wound healing. But in many intracranial and in certain spinal cord operations bleeding is so profuse that the surgeon must use every resource at his command to keep it within a safe limit.

Observations.—The determination of blood loss during operation was made by the method of Gatch and Little.[2] The hemoglobin, which is extracted from the drapes and cotton pledgets by rinsing them thoroughly

* With the single exception of a laminectomy in a case of fracture of the spine with a blood loss of 672 cc. (Gatch and Little.[2])

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in a known amount of water is converted to acid hematin by the addition of hydrochloric acid. The color intensity of the unknown sample is then measured against a standard containing 1 cc. of the patient's blood obtained preoperatively, diluted to 100 cc., and acidified. The calculated volume of blood lost is probably from 5 to 10 per cent less than the actual amount because of the difficulty of recovering all the hemoglobin from the dry goods, instruments, and the floor of the operating room. Since this work has been completed, Pilcher and Sheard[4] have described a more sensitive method of quantitatively estimating blood loss in which the hemoglobin content is measured by a spectrophotometric and photelometric method, but for the purposes of this investigation the method of Gatch and Little should be sufficiently exact.

Table I shows the amount of blood lost in a series of 37 standard neurosurgical operations. This should be compared with the data in Table II obtained by Gatch and Little[2] and by Coller and Maddock[3] in a series of general surgical operations. The greatest loss of blood recorded in Table II, 1,272 cc., occurred in a radical resection for carcinoma of the breast. Our maximal blood loss, 2,150 cc., took place during the removal of a large frontoparietal meningioma (Patient 5). The patient was given two transfusions, and made an uneventful recovery. The other two patients (Nos. 2 and 29) who lost over two liters of blood did not survive. In Patient 2, a meningioma of the cribriform plate, death appeared to be related to the hemorrhage and shock. In Patient 29, however, the hemorrhage was well compensated* and shock did not develop. Death in this case was presumably due to cerebral injury with consequent hyperthermia, but no autopsy was permitted. In spite of the fact that 15 of these patients lost over a liter of blood, only two developed severe postoperative shock, and only one death was attributable to a reduced blood volume. The reason a greater loss of blood can be tolerated in intracranial than in intra-abdominal operations will be considered later in the discussion. In no instance where an extensive craniotomy was performed was the loss of blood less than 487 cc. Where no resection of brain tissue was carried out, the hemorrhage occurred mainly during the closure of the scalp. When the skull is not excessively vascular, careful hemostasis can reduce the amount of bleeding during the incision of the scalp and turning down the bone flap to an amount not in excess of 100 cc., but bleeding when the hemostats are removed and the stitches are placed in the galea is more difficult to control.

To summarize the volumes of blood lost during operation by three different surgeons, it was found that in simple craniotomies, where nothing more than an exploration and cerebral biopsy was carried out, the average loss amounted to between 500 and 900 cc. (Table I.) In patients with

* The term "compensation," as applied in this article to the reaction of the body to hemorrhage, does not imply restoration of the red blood corpuscles or plasma volume. It simply means the maintenance of a relatively adequate supply of blood to the heart and vital organs through the hemostatic activity of the sympatho-adrenal mechanism.

TABLE I

BLOOD LOSS AND EARLY POSTOPERATIVE REACTIONS IN A SERIES OF 37 NEUROSURGICAL OPERATIONS

Transfusions averaged 500 cc. of citrated blood

Patient	Age	Operation	Anesthetic	Time—Hours	Blood Loss Cc.	Shock	Transfusion	Postoperative Course
1.	47	Partial removal of left frontoparietal glioblastoma multiforme	Local	2¾	1,449	0	0	Died in 17 hours. Autopsy showed herniation of cerebellum into foramen magnum
2.	56	Exploration and decompression of meningioma of cribriform plate	Local	3¼	2,023	++	2	Died in 40 hours, probably from intracranial hemorrhage. No autopsy
3.	14	Exploration for epilepsy	Avertin and local	2¼	964	0	0	Uneventful
4.	24	Excision of cerebral cicatrix for epilepsy	Local and evipal	3	1,456	0	1	Uneventful
5.	26	Removal of large frontoparietal meningioma	Local	2	2,150	++	2	Uneventful
6.	25	Negative cerebral exploration	Local	2¼	542	0	0	Uneventful
7.	20	Bone flap to evacuate subdural hematoma	Local and ether	2¼	599	0	0	Uneventful
8.	37	Resection of meningioma of tuberculum sellae	Local	2½	574	0	0	Patient did well at first, but then slipped into coma and died on the ninth day
9.	15	Laminectomy for extreme scoliosis with cord compression	Avertin and ether	1¾	334	0	0	Uneventful
10.	51	Partial removal of acoustic neuroma	Local	4½	638	0	0	Died on second day. Cause of death was not explained by postmortem
11.	44	Laminectomy for arachnoiditis	Avertin, local and ether	1½	1,264	+	0	Uneventful
12.	16	Cervicothoracic ganglionectomy	Avertin and local	1	107	0	0	Uneventful
13.	53	Section of fifth cranial nerve root for trigeminal neuralgia	Local and evipal	1	86	0	0	Uneventful
14.	22	Partial removal of glioblastoma multiforme	Local	2¾	1,333	+	1	Good convalescence for 6 days. Died on ninth day of epidural hematoma
15.	42	Negative cerebral exploration	Local	2½	1,100	0	0	Fair convalescence. Subsequently reexplored, abscess drained, patient died
16.	51	Evacuation of cerebellar cyst	Local	2¼	1,176	+	1	Died on eighth day. Autopsy did not reveal cause of death
17.	14	Partial resection of ependymoma of third ventricle	Avertin and local	3½	620	0	0	Uneventful
18.	31	Excision of cerebral cicatrix for epilepsy	Local and evipal	3¾	1,300	0	1	Uneventful
19.	46	Partial excision of temporal lobe glioma	Avertin and local	4¼	900	0	1	Slow recovery with herniation of brain and clouded mentality
20.	41	Exploration of third ventricle	Avertin and local	4	700	0	0	Uneventful
21.	27	Excision of cerebral cicatrix for epilepsy	Local	3¼	1,330	0	1	Died in 40 hours, probably acute perforation of esophagus or stomach. No autopsy

TABLE I (*Continued*)

Patient	Age	Operation	Anesthetic	Time—Hours	Blood Loss Cc.	Shock	Transfusion	Postoperative Course
22.	46	Cervical cordotomy and posterior root section	Gas-oxygen and local	2½	1,034	+	1	Uneventful
23.	7	Cranioplasty for premature closure of sutures	Avertin and local	1¾	630	0	0	Uneventful
24.	28	Suboccipital decompression for arachnoiditis	Avertin and local	3	1,010	0	1	Uneventful
25.	45	Removal of large meningioma of sphenoid ridge	Local and evipal	4½	1,570	+	1	Spinal fluid leak and meningitis. Died in 3 weeks
26.	29	Removal of neurofibroma of lumbar cord	Avertin and local	2	860	0	0	Uneventful
27.	53	Cervical cordotomy	Local and gas-oxygen	1¾	550	+	0	Uneventful
28.	46	Partial removal of pituitary adenoma	Avertin, local and ether	2½	1,200	0	0	Died in 8 hours
29.	54	Subtotal resection of meningioma of sphenoid wing	Avertin and local	2½	2,050	0	1	Died on fourth day
30.	53	Partial removal of glioblastoma multiforme	Local and ether	3	753	0	1	Period of coma due to cerebral edema, followed by recovery
31.	15	Negative cerebellar exploration	Local	2¾	927	0	1	Uneventful
32.	16	Myoplastic craniotomy for oxycephaly	Avertin-ether and novocain	1¼	487	0	0	Uneventful
33.	21	Parietal bone flap and evacuation of subdural hematoma	Avertin-ether and novocain	2	918	0	0	Uneventful
34.	47	Negative cerebellar exploration	Local	2½	708	0	1	Uneventful
35.	57	Total resection of meningioma of frontal lobe	Local	1¾	1,187	0	1	Uneventful
36.	28	Frontoparietal exploration and biopsy	Local and ether	1¼	1,050	0	1	Transitory hemiparesis
37.	53	Subtotal resection of frontoparietal astrocytoma	Local	2¼	1,289	0	0	Transitory hemiparesis with complete recovery

relatively avascular tumors, the loss of blood rose to between 600 and 1,200 cc. In three patients with large meningiomata, the hemorrhage exceeded 2,000 cc.* In five laminectomies the loss of blood varied from 334 to 1,263 cc. A hemorrhage of over a liter in the course of an operation on the spinal cord may seem excessive, but with an epidural abscess or a vascular tumor, or in a hypertensive patient, both the muscles and the bony lamina may bleed profusely. Indeed, in a patient with a hemangioma and compression of the spinal cord, the attempt to expose the tumor had to be given up after two trials on account of severe hemorrhage. On the other hand, in two patients where cervicothoracic ganglionectomy and section of the fifth

* Since this article was submitted for publication one of us, W. H. S., has carried out additional determinations of blood loss in Dr. P. Bailey's clinic at the University of Chicago. The results there were similar to those reported above, with a maximum of 1900 cc. during the removal of a meningioma.

cranial nerve root were carried out, bleeding amounted to only 107 and 86 cc., a volume comparable to that which has been reported in routine appendicectomies and herniorraphies (Table II).

TABLE II

BLOOD LOSS DURING ORDINARY SURGICAL OPERATIONS

From Statistics by Gatch and Little,[2] and Coller and Maddock[3]

Gatch and Little		Coller and Maddock	
Operation	Amount of Blood Lost Cc.	Operation	Weight of Blood Lost Gm.
1. Abdominal Incisions:		1. Partial gastric resection	111
A. Midline or right rectus:		2. Exc. thyroglossal cyst	174
1. Suspension of uterus, appendicectomy	22	3. Exploratory, kidney	208
2. Hysterectomy, appendicectomy	209	4. Repair inguinal hernia; appendicectomy	54
3. Suspension of uterus (Baldy-Webster)	28	5. Repair ventral hernia	92
4. Panhysterectomy	310	6. Exc. sarcoma thigh	161
5. Appendicectomy	17	7. Exc. teratoid tumor abdomen	546
6. Panhysterectomy for large fibroids	304	8. Radical mastectomy	1,272
7. Hysterectomy, appendicectomy	206	9. Partial gastric resection	274
8. Gastrectomy, Polya method, carcinoma	232	10. Colostomy	13
9. Cholecystectomy	51	11. Repair inguinal hernia	13
10. Cholecystectomy	66	12. Repair ventral hernia	147
11. Cholecystectomy	145	13. Hemorrhoidectomy	8
12. Exploratory celiotomy, appendicectomy, plastic operations on both ovaries	120	14. Repair inguinal hernia	51
13. Exploratory celiotomy	14	15. Appendicectomy	14
14. Appendicectomy, repair of abdominal wound and separation of adhesions	62	16. Cholecystectomy	55
B. Hernia:		17. Appendicectomy	13
15. Left inguinal	11	18. Repair ventral hernia	306
16. Left inguinal	32		
C. McBurney:			
17. Appendicectomy	4		
18. Appendicectomy	7		
19. Appendicectomy	6		
20. Appendicectomy	8		
21. Appendicectomy	7		
22. Appendicectomy	6		

TABLE II (*Continued*)

Operation	Amount of Blood Lost Cc.
2. Other Operations:	
23. Thyroidectomy	504
24. Thyroidectomy, adenomata, local	16
25. Thyroidectomy, adenomata	61
26. Thyroidectomy	252
27. Radical breast amputation for cancer: removal of pectoral muscles and axillary évidement	710
28. Double simple breast amputation for nonmalignant disease	400
29. Double simple breast amputation for nonmalignant disease	420
30. Drainage, acute osteomyelitis of humerus	176
31. Sequestrectomy, tibia	59
32. Sequestrectomy, tibia	40
33. Laminectomy, fracture of spine	672
34. Amputation of middle finger, metacarpophalangeal joint	44
35. Nephrectomy, left lumbar	816

It is obvious that the excessive bleeding which occurs in the usual neurosurgical operation is due to certain regional conditions which are not encountered in the ordinary procedures within the abdominal or thoracic cavities, or in the extremities. In operations on the brain and spinal cord, hemostasis is rendered difficult because of the extreme vascularity of the scalp and the muscles of the back, and owing to the problem presented by the control of bleeding in the course of the elevation and closure of the bone flap or during the resection of the spinal laminae. In the removal of vascular meningiomata, and other brain tumors, the problem is further complicated by the difficulty of rapidly locating and controlling the vessels in the depths of the wound. In operations on the sympathetic structures and the peripheral nerves, these conditions are not encountered and the loss of blood is no greater than in other surgical procedures.

Another matter of interest is the protracted reduction of the concentration of red blood corpuscles, hemoglobin, and hematocrit readings which continue progressively for from four to six days after operation. These

TABLE III

HEMOCONCENTRATIONS AFTER NEUROSURGICAL OPERATIONS

	Patient 6			Patient 7			Patient 8			Patient 13			Patient 15			Patient 29			Patient 30		
Blood Loss: Cc.	542			599			574			86			1100			2050			753		
	R.B.C.	Hb.	Hematocrit	R.B.C.	Hb.	Hematocrit	R.B.C.	Hb.	Hematocrit	R.B.C.	Hb.	Hematocrit	R.B.C.	Hb.	Hematocrit	R.B.C.	Hb.	Hematocrit	R.B.C.	Hb.	Hematocrit
Preop.	4.54	79	42	5.15	95	42	3.95	84	40	4.75	79	43	4.62	55	32	6.2 Transfusion	93	45	4.42 Transfusion	87	44
Postop.	4.23	81	39	4.39	81	37	4.30	87	44	4.71	82	41	4.57	60	31	5.3	84	41			
1st day	4.01	76		3.61	72		3.64	77		4.64	73		4.11	58		5.1	82	43	3.96	75	36
2nd day	4.02	68	33	3.26	70		3.81	67	33	4.03	79	40	3.39	48		5.0	81	44			
3rd day	4.07	72		3.59	70	34	3.32	68		4.28	76		3.59	47		5.4	85	40			
4th day	3.67	63	34	3.12	74		2.99	57	29				3.19	46		Died			3.49 Transfusion*	70	37
5th day	4.03	71			69					3.99	81		3.43	50	22						
6th day	3.63	69		3.36	72	30	2.94	66					3.62	52							
7th day	3.65	70	34.5	4.13	71		3.40	84	34				3.79	48					2nd Operation Transfusion*		
8th day	3.67	71												49					3.74	83	38
9th day	3.29	67		4.04	80	32							3.71	54							
10th day	3.89	72	36	3.88	85								3.59	47					4.33 Transfusion*	101	45
12th day				4.13	87	34							3.77	50							

* Transfusions for low serum protein.

	Patient 31			Patient 32			Patient 33			Patient 34			Patient 35			Patient 36			Patient 37		
Blood Loss: Cc.	927			487			918			708			1187			1050			1289		
	R.B.C.	Hb.	Hematocrit	R.B.C.	Hb.	Hematocrit	R.B.C.	Hb.	Hematocrit	R.B.C.	Hb.	Hematocrit	R.B.C.	Hb.	Hematocrit	R.B.C.	Hb.	Hematocrit	R.B.C.	Hb.	Hematocrit
Preop.	4.18 Transfusion	78	38	5.03	75	34	4.64	105	45	5.65 Transfusion	85	51	4.56 Transfusion	86	40	4.46 Transfusion	94	41	5.36	87	45
Postop.																					
1st day	3.51	60	39	5.01	60	33	4.17	75	33	5.24	80	44	3.38	63	31	3.82	77	37	4.59	84	42
2nd day																					
3rd day	3.97	65	32	4.86	58	31				5.13		43	3.85	66	26	3.77	63	34	4.86	84	30
4th day							3.36	60	33												
5th day				5.57	66	33															
6th day																3.13	63	32	4.58	75	28
7th day	3.78	60	26				3.12	38	23	5.56	80	42	3.72	68	32						
8th day							Transfusion†														
9th day	Transfusion†																				
10th day							3.51	67								–					
12th day	4.79	80																			

† Transfusions for anemia.

Transfusions contained approximately 500 cc. of citrated blood.

Hemoglobin measured by Sahli method.

data are presented in Table III. In patients whose blood changes were followed for two weeks, the erythrocyte count, hemoglobin, and hematocrit reached a minimum between the fourth and sixth days after operation. These concentrations then gradually increased, returning approximately halfway back to their preoperative levels within a ten-day period. Theoretically, one might expect the maximum reduction of erythrocytes, hemoglobin, and hematocrit to take place within 12 hours after operation, as the reduced number of red blood cells are diluted by tissue fluid entering the blood vessels. Independent observations made by Dr. John Talbott[5] at this hospital confirm our observations. He interprets the continued reduction in the concentration of red corpuscles as a depression of the blood-forming elements in the body.

Methods of Reducing Hemorrhage at Operation.—A valuable means of controlling bleeding during craniotomies is the anesthetic. A wide infiltration of the scalp with a 1 per cent novocain-epinephrine* solution diminishes bleeding. Our preference is to supplement this with basal avertin, as this drug produces a moderate fall in blood pressure and thereby diminishes hemorrhage from the cerebral vessels. In addition to this, basal narcosis contributes to the comfort of the patient and reduces nervousness and restlessness. In patients who cannot tolerate avertin because of hypertension or poorly functioning kidneys, we have employed preliminary phenobarbital, nembutal, or paraldehyde narcosis in conjunction with a thorough regional infiltration. Occasionally this must be supplemented with a very light ether anesthesia when the patient is extremely nervous or uncooperative. Morphine, as is generally known, cannot be used with safety in individuals with increased intracranial pressure, because of its depressing effect on the respiratory center.

Administration of the general anesthetics ether and nitrous oxide should be avoided whenever possible because they increase bleeding. In the case of ether, the work of Finesinger and Cobb[6] has demonstrated that this drug, like alcohol, acts as a vasodilator on the cerebral vessels. As a result, satisfactory hemostasis is not only more difficult to achieve, but the vascular network in the brain is engorged and the working space within the cranial cavity correspondingly reduced. Nitrous oxide-oxygen anesthesia also produces increased bleeding because it so frequently causes partial asphyxia, and is worse than ether on account of the secondary elevation in blood pressure which goes with it. When a general anesthetic must be used, a preliminary infiltration of the scalp with 0.5 per cent novocain-epinephrine solution is of value not only as a hemostatic agent, but also because a lighter level of anesthesia can be employed.

While details concerning the surgical technic of hemostasis are outside the scope of this paper, it is nevertheless important to point out that the surgeon can always afford sufficient time to carry this out with the most

* For the purpose of local vasoconstriction, 0.2 cc. of a 1:1,000 solution of epinephrine should be added to each 100 cc. of novocain.

meticulous care. It should be emphasized that neurosurgical patients tolerate prolonged operations well and that in our opinion postoperative shock depends on trauma to the brain and the amount of blood shed rather than on the duration of the operation. A brisk hemorrhage coming late in the resection of a brain tumor, when the vascular system has reached its limit of compensation, is serious. Such a complication can never be foreseen, but much can be done to forestall its depleting effects by constant attention to hemostasis and the maintenance of a maximum reserve of blood within the vascular bed. Time taken to control bleeding is never wasted.

One further point concerning hemorrhage at operation should be mentioned. If the neurosurgeon will measure the volume of blood lost during a series of operations, he may develop the ability to make a fairly accurate estimation by inspection of the drapes, the bucket which contains discarded gauze and cotton pledgets, and the contents of the suction bottle. Assuming a hemorrhage of 1,200 to 1,500 cc. as the upper limit of the average patient's ability to compensate for reduced blood volume,* it is better either to give an immediate transfusion or to postpone the total extirpation of a tumor to a second session when this point is reached.

It will be seen on examining the statistics on blood loss given in Table I that these actual measurements have served to make the members of our neurosurgical operating team "hemorrhage conscious." During the three year period of this investigation every effort has been made to promote more effective hemostasis, and the improvement in the latter third of the series has been distinctly encouraging.

Replacement of Blood Lost during Operation.—The customary procedure on the Neurosurgical Service has been to start an intravenous infusion of 5 per cent glucose in normal saline at the beginning of every extensive operation and to permit 500 to 1,500 cc. to run in slowly during the operation. Citrated blood may then be substituted for the saline solution whenever there is an alarming fall in blood pressure. When it is estimated that a hemorrhage of a liter or more has occurred, a transfusion is given before the patient is sent to the ward. After hemorrhages exceeding 1,200 to 1,500 cc., or whenever the blood pressure remains at a critically low level, multiple transfusions are given. This can be carried out on the ward if the intravenous infusion has been kept running. The total fluid intake on the day of operation should rarely exceed 2,000 cc.,[1] and should be given slowly over a period of five to eight hours.

Discussion.—From the data we have presented on blood loss during operations on the central nervous system, emphasis must be laid on certain fundamentals which differentiate this special field of surgery. The outstanding feature is the increased volume of hemorrhage, which is from two to five times greater than in routine celiotomies. Again, although a liter of blood is lost during the average operation for brain tumor, these patients

* Such an extensive hemorrhage can be tolerated only if it takes place gradually during a three or four hour operation.

rarely go into surgical shock, unless the hemorrhage is rapid or exceeds 1,200 cc. Experience with transfusion donors has taught that a healthy individual can withstand a sudden bleeding up to 500 or 600 cc. While rapid hemorrhage above this amount will cause characteristic symptoms, a slow loss of twice this volume over a period of three to four hours can usually be tolerated. This situation is quite different from that which is encountered in operations on the abdominal viscera. Here no such extensive bleeding can be withstood because it takes place in a much shorter space of time. In addition, water is lost by vaporization from the skin and lungs at a more rapid rate.[1] These and other, as yet poorly understood, factors tend to produce surgical shock to a greater degree than during intracranial procedures of apparently greater severity and duration.

Because sudden brisk hemorrhage may occur at any time during brain tumor resections and throw the patient into a state of uncompensated blood loss, it is of extreme importance to preserve every possible drop of blood and to be able to replace any excessive reduction in blood volume without delay. The latter is accomplished by the constant intravenous administration of a 5 per cent solution of glucose in normal saline during operation, with a compatible donor waiting in an adjacent room. In sudden uncompensated hemorrhage the surgeon is thereby prepared for the transfusion of citrated blood and the deficit can be restored with the minimum loss of time.

SUMMARY

(1) Hemorrhage in the course of extensive intracranial operations averages from 500 to 1,500 cc. This is from two to five times greater than the usual volume lost in other types of operations.

(2) In spite of excessive bleeding, neurosurgical patients rarely go into shock if less than 1,200 cc. of blood is lost, unless the hemorrhage is rapid, or damage is done to the centers which control circulation and respiration.

(3) Hemorrhage during operation can be reduced by:

(a) Meticulous hemostasis. As neurosurgical patients withstand a protracted operation well, time consumed in cutting down the loss of blood is never misspent.

(b) Choice of the anesthetic. Ether anesthesia causes excessive bleeding secondary to dilation of the cerebral blood vessels. Similarly, the administration of nitrous oxide commonly results in a rise of blood pressure and an increase in bleeding. The most effective means to reduce hemorrhage is the infiltration of novocain-epinephrine solution in the scalp. This may be supplemented by avertin or by one of the barbituric acid derivatives if a basal narcosis is desired.

(4) Replacement of blood lost during any extensive craniotomy is best carried out by a constant intravenous infusion of 5 per cent glucose in normal saline. One thousand to 1,500 cc. administered in this way will take care of a gradual loss of a liter of blood. After a sudden brisk hemorrhage, or failure of the organism to compensate for an excessive loss

of blood, the infusion apparatus is available for the transfusion of citrated blood.

(5) Our determinations have shown that ordinarily a single transfusion of 500 cc. is sufficient after a hemorrhage of from 1,200 to 1,500 cc. When over this amount has been lost, or the blood pressure has failed to respond to the first transfusion in the operating room, the intravenous drip apparatus serves for a subsequent transfusion of blood on the ward.

(6) The neurosurgeon should be able to make a reasonably accurate estimate of the volume of blood lost in the course of an operation. Recognizing a hemorrhage of 1,500 cc. as the maximum amount that can be tolerated by an average patient, it is advisable to transfuse or to postpone the total extirpation of a tumor to a second stage when this limit is approached.

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GIANT CELL TUMOR OF THE CERVICAL SPINE

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GIANT cell tumor of the cervical spine is a comparatively rare lesion. The common sites for this type of tumor, in order of frequency, are the lower end of the femur, the upper end of the tibia, the lower end of the radius and the upper end of the humerus. Some difficulty is encountered in estimating its frequency of occurrence in the vertebrae because of the repetition of cases reported in the literature. If this source of error can be disregarded, giant cell tumor is found in the vertebrae in 8 per cent of the cases. The cervical vertebrae are reported involved in seven instances. If statistics can be relied upon this represents 1 per cent of the total number of cases of giant cell tumor occurring in the vertebrae, and 15 per cent of the vertebral lesions (Table I).

TABLE I

FREQUENCY OF CERVICAL INVOLVEMENT AMONG THE REPORTED GIANT CELL TUMORS OF THE VERTEBRAE

Reporter	Year	No.	Involvement of Cervical Vertebrae
Dean Lewis[1]	1924	17	1
Kolodny[2]	1928	8	?
Simmons[3]	1931	4	1
Geschickter & Copeland[4]	1935	8	0
Meyerding[5]	1936	4	1
Peirce & Lampe[6]	1936	5	0
Simmons[7]	1936	3	3
Bosworth[8]	1936	1	1
Buzby[9]	1936	1	0
Harbin[10]	1937	3	0
Osgood[11]	1937	1	1
Compere[12]	1937	1	0
		56	8

The age of the individual is, in a decided majority of all giant cell tumors, above 20, the oldest being 68 and the youngest four and one-half years. In the vertebral lesions the majority are under the age of 20. The sexes are about equally represented.

Giant cell tumor is classified as nonmalignant. Coley, however, in reporting 50 cases, states that ten died of metastases. Meyerding[5] reports but one death from metastases in 61 cases. Both Simmons,[3, 7] and Kolodny[2] deny the possibility of metastasis unless the tumor changes its characteristics. Geschickter and Copeland[4] recognize a "malignant variant, which is usually the result and not the cause of recurrence." This would indicate that inadequate

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removal or treatment is responsible for this secondary change. They also claim if this "malignant variant" structure is primary, and recurrence results, metastasis is apt to follow!

Geschickter and Copeland claim that the giant cell tumor, occurring in the small bones (ribs, metacarpals, metatarsals, laminae of spine, *etc.*) are spindle cell variants. (Giant cell tumors have a stroma of round cells with few spindle cells. In the "variant" the number of spindle cells is increased.) In 37 of these cases there were no recurrences except an inoperable one of the sacrum, in which a laminectomy was attempted. In Dean Lewis'[1] series of 17 vertebral tumors, 13 healed after partial removal. He emphasized this significant response, since ossification of the site of giant cell tumors of the long bones is extremely rare unless the tumor is completely removed or destroyed.

The treatment of giant cell tumors, in general, cannot be proven by statistics. Many have been subjected to combinations of radiation, curettage, cauterization, Coley's toxins, resection and amputation. Simmons, Meyerding, and Geschickter and Copeland all agree that there were no deaths or recurrences following either amputation or resection.

Following curettage alone, Simmons reports 19 cases with one death from hemorrhage and one recurrence. Geschickter and Copeland, in 105 cases, find one death and 31 recurrences. Of the recurrences, 16 were cured after a second or third curettement, seven had secondary infection with three amputations. Bloodgood states that 80 per cent are cured by curettement. He recommends cauterization of the base with pure phenol, then 95 per cent alcohol and finally zinc chloride. Meyerding reviews ten in which he partially filled the cavity with a bone graft following the curettage. None of these cases had recurrences.

Radiation is usually combined with other methods of treatment. There are, however, a few cases reported in which radiation alone was used. Simmons states in eight cases there were six cures, one death, one amputation. Geschickter and Copeland in ten cases find that five came to subsequent surgery.

From these reports, if it is not too presumptuous to conclude, the treatment of choice would be curettement. This failing, resection or amputation must be performed.

Case Report.—A white female, age 9, was brought to the Children's Hospital clinic in May, 1936, because her head tilted to one side. This had been noticed six months previously. No pertinent history, other than a tonsillectomy ten months before, could be obtained.

Physical Examination showed the head tilted to the right 30° and rotated to the left 20°. There was slight limitation of rotation to the right and lateral flexion to the left. Reflexes and sensation were normal, but there was some atrophy of right arm and evidence of muscle weakness, especially loss of power in grip of right hand. Upon questioning, the child admitted a sensation of "numbness of the fingers."

A roentgenogram at this time was interpreted as showing a forward dislocation of the right inferior facet of the third cervical vertebra. Hyperextension failing to reduce this lesion after two weeks, a Walton manipulation was made and a plaster bandage applied to head and torso.

The patient returned in July for a change of the plaster encasement. Examination failed to elicit any sensory or motor disturbances. There was at this time a fulness of the neck on the right side of the spinous process of the fourth cervical vertebra. Roent-

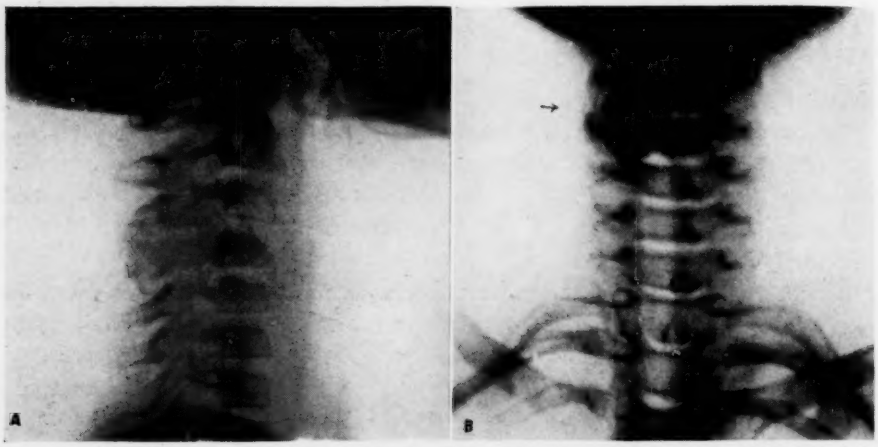

FIG. 1.—(A) Roentgenogram (lateral view) showing shadow of cystic tumor mass on the right side of the fourth cervical vertebra projecting posteriorly. (B) Anteroposterior view.

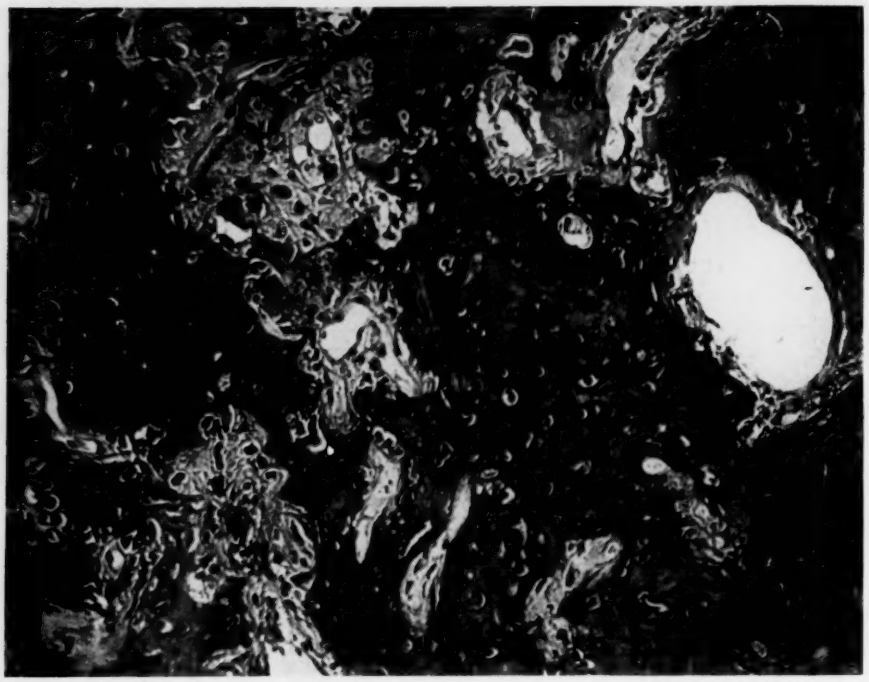

FIG. 2.—Photomicrograph showing typical giant cells in a stroma of round cells containing many spindle cells.

genologic examination showed a rounded cystic tumor projecting posteriorly from the fourth cervical vertebra (Fig. 1, A and B). Comparison with previous roentgenograms proved it to have been present previously as a faint irregular shadow of only one-half

the diameter of the present mass. Roentgenologic examination of the other bones and lungs proved negative. The blood calcium and phosphorus were normal.

A biopsy was performed August 14, 1936. The mass appeared well defined and localized to the fourth right cervical lamina. The spinous processes and laminae on the right side of the third, fourth and fifth cervical vertebrae were removed. Convalescence in a bivalved plaster encasement was uneventful.

Pathologic Examination.—Dr. A. D. Waltz: "Grossly the specimen consists of several pieces of bony material, the largest about 1 cm. across. The narrow inner portion is deep red in color, soft and friable, breaking away easily. The next and widest portion is also deep red but contains some bony material. The outer portion is grayish-white and hard. Microscopically the inner friable portion is made up of spindle, oval or rounded cells, profusely studded with large giant cells showing many central nuclei. The widest portion shows a network of bony trabeculae surrounding

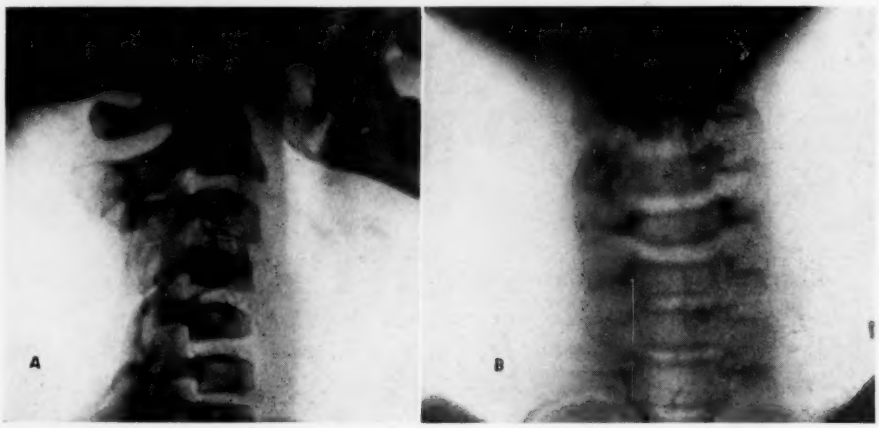

FIG. 3.—(A) Roentgenograms (lateral view) one year postoperative showing increase in bone density at site of laminectomy, indicating bony ankylosis but no evidence of recurrence of tumor growth. (B) Anteroposterior view.

larger or smaller spaces, which contain the same type of tumor and giant cell as described above. External to this is osteoid tissue, which is covered by a thin shell of hard bone. Giant cell tumor originating in the marrow cavity" (Fig. 2).

One course of roentgenotherapy was instituted by Dr. Ralph Bromer two weeks after operation. This was not repeated for fear of disturbance to the thyroid and parathyroid glands.

Roentgenologic examination, in April, 1937, showed ossification but no increased size in the suspicious involvement of the right pedicle and transverse process of the fourth cervical vertebra, which had not been removed at operation.

September 13, 1937, the patient was symptom free. Examination revealed the head tilted slightly to the left and the chin to the right of the midline. Neck motion: Extension, 30°; flexion, 45°; flexion to right, 25°; flexion to left, 25°; rotation to right, 35°; and rotation to left, 45°. One-eighth inch atrophy of upper and lower arm. No disturbance of reflexes or sensation. Roentgenologic examination at this time showed no recurrence of the tumor growth but solid bony fusion bridging the site of the laminectomy (Fig. 3, A and B).

SUMMARY

A case is reported of a female, age 9, who had a giant cell tumor of the lamina of the fourth cervical vertebra. The tumor was almost completely re-

moved by performing a laminectomy. Pathologically it resembled the spindle cell variant of giant cell tumor recognized by Geschickter and Copeland. One year after operation the patient is symptom free and roentgenologic examination does not show any recurrence.

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RATIONALE OF BONE DRILLING IN DELAYED AND UNUNITED FRACTURES

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IN ELUCIDATING as comprehensive a subject as osteogenesis in fracture repair, following the drilling operation, the following aspects must be evaluated: (1) Skeletal maturity. (2) Effect of local environmental biophysical states upon bone production. (3) Normal bone a balanced physiologic mechanism. (4) Possible physiologic effects resulting from the drilling operation.

Skeletal Maturity.—In the phenomenon of skeletal maturity is comprehended not only the maturation of the component bones of the skeleton, but in addition, a mechanism which controls and coordinates the linear and volumetric relations of these components one to the other—acceleratory and inhibitory influences.

For the growth of a bone its resident center of ossification is most essential. Quite as necessary, however, for properly coordinated growth and solidity, are the pituitary and parathyroid secretions. The factor of adequate local circulation is assumed in either developing bone or in the process of its repair.

This mechanism presents quite a striking similarity to the heart with its associated vagosympathetic influence. The heart muscle, while automatic, is at all times subject to the tonic activity of the craniobulbar outflow of nervous impulses on the one hand, and the sympathetic autonomic impulses on the other, the resultant cardiac response being the algebraic sum of the two opposing influences.

In the case of a bone, its growth is intimately dependent upon its ossification center. The activity of this center and the consequent development of the bone are determined by the pituitary (in close association with the craniobulbar outflow) and the parathyroid secretions (in close association with the sympathetic autonomic outflow). The ascendancy of pituitary function may result in acromegaly or gigantism, while preponderance of the parathyroid secretion may result in destruction of bone or Recklinghausen's disease.

Effect of Local Environmental Biophysical States upon Bone Production.—Following a previous statement that the ossification centers determine the limits of the mass of a bone subject to the secondary influences of hormones elaborated by the pituitary, parathyroid and perhaps other glands, the actual deposition of bone is a synthetic reaction occurring immediately at the site of bone production. The differential importance of the various components of the bone in the process of new bone formation has been conclusively demonstrated.

Conclusions from the clinical application of bone grafts are, however, open

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to question in the light of present facts: The work of Ollier,[1] McWilliams,[2] Phemister, *et al.*, confirmed the findings of Duhamel, in the mid-eighteenth century, concerning the prime importance of the periosteum in osteogenesis. Based upon similar corroboration, Mock,[3] Delangeniere,[4] Albee,[5] and Haas[6] insist upon bone grafts containing periosteum.

The *in vitro* studies of Dobrowolskaja[7] revealed slight bone growth from periosteum alone, steady bone growth from pieces of cortical bone alone, and luxuriant growth from spongy bone containing marrow. Ollier,[1] Barth,[8] Axhausen,[9] Macewen,[10] and Groves[11] have demonstrated that a tube inserted into the medullary canal soon became filled with bone. Johnson[12] showed that when the nutrient arterial supply to the bone marrow and inner one-half of the cortex is intact, it is productive of a much more rapid bone repair than is the case with the blood supply to the periosteum and outer one-half of the cortex. Berg and Thalhimer[13] felt they obtained even greater growth from those transplants containing endosteum than from those including periosteum.

Therefore, in the clinical application of bone grafts there is insufficient control of the components of the grafts or its recipient to permit of trustworthy conclusions. The weight of evidence, however, definitely favors endosteum over periosteum as a source of osteogenesis.

In a series of very well controlled experiments, McGaw and Harbin[14] attempted to determine the use of bone marrow and endosteum as a free graft to stimulate or hasten osteogenesis. A small mass of marrow and endosteum removed from the tibia in dogs was substituted for a three-eighths inch resected segment of fibula in the same subject. The opposite fibula was similarly resected for control. They concluded that: "Bone marrow and endosteum play a very active rôle in the formation of callus and new bone in dogs." There are now well controlled series of human experiments which confirm this.

The experimental studies upon hyperparathyroidism show conclusively that the halisteresis, or solution of mineral salts, is a local reaction at the interphase between tissue fluids and the bone. The secondary effects of narrow zones of decalcification of trabeculae, haversian canal, subperiosteal and endosteal surfaces result only from the foregoing phenomenon. Conversely there is incontrovertible evidence that bone synthesis or production is a similar local surface process.

The local question arises: What are the causative biophysical processes underlying this mechanism of bone production? It is not sufficient to state that certain important bone constituents and adequate circulation are imperative. At present all of the chemical and physical requirements are not known.

Rosahn[15] recently reported the serum phosphatase content of a group of normal rabbits varying in age from 15 to 71 days. He found the phosphatase values in this group to describe a significant linear decrease with increasing age and weight. Such findings might logically be anticipated since all bones of the body are growing, the sum total of the local reactions being equivalent

to a general reaction, thereby increasing this enzyme in the general circulation.

That bone repair is a local phenomenon has been conclusively demonstrated by Wilkins and Regan[16]: In an adequately large series of perfectly controlled experiments upon rabbits, phosphatase determinations were made of the fracture foci at increasing intervals following the experimental production of comminuted fractures of both ulnae. They conclude that: "Following fracture of adult rabbit bone there is a rapid rise in the phosphatase activity at the site of bone injury which reaches a peak at some time near the twenty-second day and drops gradually as repair progresses." They also state that: Some of the rabbits showed a slight elevation of plasma phosphatase at the time when the phosphatase activity at the site of fracture was maximum. This elevation was so slight that its significance is questionable.

Phosphatase determinations on the foreleg bones after removal of the fractured segment in the two 56 day animals gave figures within the normal range of the unfractured whole foreleg bones. While the number of experiments is too small to permit of indisputable conclusions, it is more than suggestive that enzymic activity associated with bone repair is limited to the site of the bone injury.

Since the above experimental evidence demonstrates the unquestionable presence of local phosphorus anabolism in fracture repair, it might logically by hypothecated that at least two other phenomena occur simultaneously. Calcium is deposited during this process. Its deposition may result from enzymic synthesis or electrolytic concentration at certain cellular or membrane interphases. As yet there is no evidence to support either hypothesis.

The laying down of fibroblasts and endothelial tissue for sustentacular and circulatory functions, respectively, in soft tissue, does not result in mineral deposition as in the case of osteogenesis. The presence of these tissues, however, is universal in successful bone repair. Wherein then does bone repair differ from ordinary soft tissue repair? As shown above, the cells of bone marrow and endosteum play a very active rôle in new bone formation. It seems logical, therefore, to suppose that locally a system of fibroblasts is formed in the meshes of which the periosteal, endosteal and marrow cells are supported. The rapidly growing endothelial cells develop into a sustaining circulatory network which permits of the elaboration of such enzymes by the bone cells as are necessary for the production of new bone.

Normal Bone a Balanced Physiologic Mechanism.—Before attempting to discuss this subject, a comparison of certain generalized destructive bone diseases such as Recklinghausen's disease, osteomalacia, Paget's disease and senile atrophy may be informative.

A well advanced case of Recklinghausen's disease is characterized by: Thinned cortex, porosity, bone cysts, osteoclasts with their Howship's lacunae and marrow fibrosis, grossly and microscopically. Biologically there is a decrease in serum phosphorus and an increase in both the serum calcium and

phosphatase. There is an associated increase in urinary excretion of calcium.

Regardless of any concept of a hormonal effect by the parathyroids in the etiology of this disease, there is not only definite evidence of complete lack of osteogenetic activity by periosteum, endosteum, cortex and medullary substance, but a positive swing in the direction of osteoclasis. In osteomalacia the bones show wide osteoid margins, very little marrow scarring and relatively few osteoclasts. Chemically a marked reduction in serum calcium is shown, the greater portion being excreted through the bowel. From these facts one might hypothecate an attempt at osteogenesis, particularly by the periosteum with a concomitant failure of mineral anabolism.

Lamellation and thickening of the cortex of long tubular bones without giant cell tumors and cysts, as in Recklinghausen's disease, characterize Paget's disease. The blood reveals a very high phosphatase content. There is no mineral imbalance. Herein is demonstrated a hyperosteogenetic function by the periosteum with commensurate mineral deposition and a concomitant increase in phosphorus enzyme.

Senile osteoporosis is a process of chronic atrophy of bone. In a very advanced case may be seen oily cysts due to liquefaction of marrow fat, in some of the long bones. This disease represents a failure of histogenesis on the part of the bone components and an inability to retain the minerals previously present.

Considering the bone locally, eliminating any attempt at conjecture or hypothesis concerning the primary etiology of the above pathologic states, a dissociation between cellular activity and mineral metabolism is immediately obvious. For example: Contrasting Recklinghausen's disease with Paget's disease, there is not only a negative reaction by the cellular structure but active destruction. There is also loss of mineral substance from the bone. In Paget's disease on the other hand, there are cellular production and addition of minerals. There is positive cellular reaction with loss of minerals in osteomalacia, and finally in senile osteoporosis there is little or no cellular change but marked loss of minerals.

After correlating all of the above facts and hypotheses, it would seem that in growing bone the processes of cellular proliferation and mineral deposition are simultaneous, the balance being in the positive phase. In certain destructive diseases of bone, as Recklinghausen's disease, there is a negative balance, while in normal bone the processes of osteogenesis and osteoclasis are in balance. That the mineral salts are actively held, and not merely passively present, is evidenced by their disappearance from the head of the femur after fracture in certain cases and in senile osteoporosis. This phenomenon, together with that of callus production without calcification, shows bone formation to consist of two processes, namely: Cellular proliferation and mineral deposition, and, further, that since cellular proliferation always precedes calcification, the latter process is dependent upon, and results from, the former.

Physiologic Effects Resulting from the Drilling Operation.—Notwithstanding the fact that Beck[17] is given priority in the drilling of malunited fractures by Carter, *et al.*,[18] this credit is justly due to an American surgeon.

Daniel Brainard[19] was awarded first prize by the American Medical Association, in 1854, for his essay on a "New Method of Treating Ununited Fractures." In this essay are detailed reports of successfully perforated cases of ununited fractures of radius, ulna, tibia, fibula and mandible. The method consisted in passing a spear shaped drill, called a "perforator," varying from two millimeters to more than one-eighth of an inch in diameter, subcutaneously through the healthy bone in each fragment, traversing the line of fracture. This procedure of making multiple drill holes was repeated at intervals of from five to ten days. Again, in 1858, Brainard[20] reported 13 cases of ununited fractures treated by subcutaneous perforation of the bone. The technic as described by Beck,[17] Carter,[18] Bohler,[21] Bozsan[22] and others, while varying slightly in type of instruments, site of application, *etc.*, remains identical in principle with the method originally introduced by Brainard, in 1854, in this country. In the cases herewith presented the method was highly successful in the production or stimulation of osteogenesis.

ILLUSTRATIVE CASE REPORTS

Case 1.—A. J., male, age 20, sustained a compound fracture of the middle third of the left tibia and a double fracture of the left fibula, resulting from a fall down an elevator shaft, in 1930. Slide graft effected in 1931. Graft absorbed. In 1932, the tibia was pierced ten or 12 times with bone drill. Bony union solid after three months.

Case 2.—A. U., female, age 61, slipped on an orange peel, fracturing the neck of the left femur. After reduction and the application of a plaster spica for eight weeks, no union resulted and there was a distinct slipping of the fragments. Four days after reduction and retention with a Jones traction splint, the hip was drilled according to the technic of Bozsan. Splint left in place for 16 weeks, then walking calipers. Roentgenologic examination one year after operation showed firm bony union with some absorption of neck.

Case 3.—E. L., female, age 54, fell in December, 1934, fracturing the surgical neck of the left humerus. At an open reduction operation, February 26, 1935, the coracobrachialis and short head of the biceps were found to be interposed between the fragments. The fracture was pierced eight to ten times with a drill and fixed with two Easton nails, which were removed after two months. April 10, 1935, roentgenologic examination demonstrated solid bony union.

Case 4.—V. P., female, sustained a compound fracture of the left tibia and fibula at the junction of the upper and middle thirds. Union was delayed. The fracture was drilled (Dr. J. V. Bohrer). Solid bony union was present after six weeks.

Case 5.—F. C., female, age 55, fell September 21, 1935, fracturing the right tibia and fibula at the junction of the middle and lower thirds. Treated by a plaster encasement elsewhere. The encasement was removed after five weeks and the patient allowed to walk. Nonunion resulted. Wassermann three plus. The fracture was drilled December 3, 1935, and the plaster encasement was applied for six weeks. during the last three of which the patient was allowed to walk with leg still in the plaster bandage. At end of six weeks solid bony union was present.

Case 6.—J. M., male, age 17, was thrown from a motorcycle February 7, 1934, receiving compound comminuted fractures of the right tibia and fibula at junction of middle and lower thirds. Nine months later, October 14, 1934, upon discharge from

hospital, there was a posterior bowing, false point of motion, exuberant callus, and no calcification was demonstrable by the roentgenograms. The fracture was drilled March 2, 1935. Roentgenologic examination showed increasing bony union although a false point of motion was still present. On July 16, 1935, union was firm, there was no false point of motion, and calcification was apparently present.

Case 7.—N. C., female, age 59, fell November 7, 1935, fracturing the neck of the femur at its midportion. Eleven days after reduction by the Ledbetter method and application of plaster spica, the fracture was drilled and fixed with Easton nails, because of anticipated delayed or nonunion. The nails were removed 72 days later. The plaster encasement was removed one month after removal of the nails, at which time there was roentgenologic evidence of early union. On June 15, the patient walked without support. Roentgenologic examination showed firm union at the site of fracture.

Case 8.—G. W., male, age 54, fell down a flight of stairs fracturing both the tibia and fibula in their distal thirds. The injury to soft parts was considerable. Traction was maintained for one month by a Steinman pin, followed by immobilization in a plaster encasement. There was no evidence of union after three months. Three weeks after drilling and immobilization in a plaster bandage, union was firm.

Case 9.—B. W., female, fell January 28, 1936, sustaining a subcapital fracture of the neck of the femur. Wassermann three plus. Reduction was effected by a combination of the Murray and Ledbetter methods, and a plaster spica applied. The fracture was drilled and two Easton fixation nails inserted through a window in the plaster encasement two weeks after the reduction because of anticipated delayed or nonunion. On June 30, the patient walked without support, and roentgenologic examination showed firm union at fracture site.

Case 10.—W. O'S., male, age 45, was struck by a car, December 5, 1936, sustaining a complete oblique fracture of midportion of the shaft of left tibia and fibula. Reduction and application of plaster incasement under general anesthesia. December 21, 1936, fragments were overriding and there was no union. Multiple drilling and fixation of fragments with Easton nails was effected at open reduction. January 28, 1937, nails were removed, solid bony union was evident clinically and in roentgenograms. December 13, 1937, result was excellent; no defective gait.

Case 11.—C. K., female, age 78, fell on the sidewalk December 28, 1936, sustaining a subcapital fracture of neck of femur. Immediate reduction by Leadbetter method and plaster spica. No union resulted. February 18, 1937, open reduction, multiple drilling and fixation of fragments with Westcott nail. April 10, 1937, roentgenogram showed bony callus. December 10, 1937, bony union solid. Walks without support; gait normal.

Case 12.—S. H., female, age 51, fell down stairs, February 9, 1937, fracturing neck of femur. Reduced by Leadbetter method and applied Whitman plaster spica same day. April 3, 1937, roentgenogram showed slipping of fragments. Open reduction, multiple drilling and fixation of fragments with Westcott nail. April 27, 1937, roentgenogram showed callus formation. December 13, 1937, solid bony union. Function normal.

Case 13.—A. R., male, age 23, struck by a car December 12, 1936, sustaining compound comminuted fracture of middle third of right tibia and fibula and simple comminuted fracture of middle third of left tibia. May 12, 1937, false motion very definite in left tibia. Fragments multiple drilled and plaster encasement applied. Three weeks later union was firm clinically. December 21, 1937, solid bony union with very satisfactory functional results.

Case 14.—N. C., female, age 22, on September 28, 1936, in auto accident, sustained a compound fracture right radius and ulna, two inches above wrist joint and complete transection of ulnar nerve and artery. Immediate débridement, open reduction, ligation of artery and repair of nerve were effected and plaster encasement applied. February 12, 1937, no union. Same date multiple drilling of radial fragments. March 17, 1937, multiple drilling of ulnar fragments and fixation with No. 28 stainless steel wire. Arm immobilized in a plaster encasement. Four months later solid bony union in both bones. December 20,

1937; bony union solid; circulation normal; function of ulnar nerve nearly normal. Patient recently played 25 games of tennis without discomfort.

Delay and nonunion of fractures occur with greater frequency in certain localities than in others; for example: The neck of the femur, lower third of the leg, certain carpal bones, *etc.*, because of the relative paucity of blood supply. The circulation to these areas is supplied by one relatively small artery with few or no anastomotic branches. In other localities, malunion may result from the interposition of massive impenetrable hematomata. There is evidence that the molecular dissociation of such clots inhibits the enzymic and proliferative processes so essential to new bone formation.

The drilling operation is indicated where: (a) One of the opposing fragments is viable. (b) There is a potentially adequate arterial blood supply in one of the fragments. (c) The distance between the fragments is not too great to be spanned by a reasonable amount of new bone.

The passing of a proper drill through the normal bone of both fragments traversing the fracture area: (a) Injures all coats of the arteries and veins, particularly the endothelial linings; (b) injures normal periosteum, bone cortex, endosteum and marrow; (c) leaves conduits which contain a soft pulpy mixture of the foregoing elements. Normal adult tissue of this type, when injured, resumes its embryonic capacity to reproduce itself.

Based upon all of the foregoing facts and hypotheses the production of new bone probably occurs as follows: The fibroblasts ramify throughout the multiple drill holes forming a sort of arbor. Perhaps the first element to permeate the connective tissue stroma, and aid in its completion, is the capillaries resulting from reproduction by the injured endothelial cells.

The last and slowest growing types of cells to invade those regenerating areas are those derived from the medulla and cortex of the normal bone. As the bone cells revert to the embryonal types, with capacity to reproduce, they also acquire a glandular function, in that they elaborate an enzyme or enzymes through the action by which calcium and phosphorus are taken from the blood stream and tissue fluids to be deposited within the interstices of this newly formed mass of cells.

Osteogenesis and osteoclasis are the opposite extremes of a highly complex reversible biophysical reaction. When the circulation is inadequate as in some cases of fractured head of the femur, the "N" point is necrosis and absorption of the proximal fragment—osteoclasis.

If all constituents in this highly complex reversible osteogenetic reaction are coordinated, the "N" point is represented by normal adult calcified bone.

CONCLUSIONS

The bone regeneration following the drilling operation for delayed or ununited fractures results from: (1) Injury to the fracture area with the consequent enrichment of local circulation, the so-called "freshening up" process. (2) Grinding and depositing within the drill canals the various bone cells, stimulating them to renewed embryonal activity to grow and reproduce.

(3) Causing certain of the bone cells to elaborate calcium and phosphorus conjugating enzymes so necessary for the deposition of calcium phosphate within the mass of callus, the so-called "bony callus."

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BRIEF COMMUNICATIONS AND CASE REPORTS

STAB WOUND OF THE HEART TWENTY-ONE YEARS AFTER SUTURE

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Case Report.—G. L. P., Negro, male, age 18 at the time of operation, 21 years ago, when a stab wound in the left ventricle was sutured by the author, at St. Joseph's Hospital, April 18, 1916. The patient was presented before the Philadelphia Academy of Surgery, and reported in the ANNALS OF SURGERY, **65**, 120, January, 1917.

The patient was discharged from St. Joseph's Hospital early in June, 1916, and was not seen again until May 5, 1937, when he appeared as a very muscular individual, weighing 160 pounds. Height five feet, ten inches.

He is now 39 years of age. He has married, and is the father of six children. During the intervening 21 years he has worked at hard manual labor, frequently as a longshoreman. At present he has a four plus Wassermann and a four plus Kahn reaction. It is not known how long these have existed.

Physical Examination.—May 5, 1937: Along the left side of the thorax there is an area of softening of bone and of cartilage, extending downward along the left sternal margin from the second to the fifth rib, measuring 7.1 by 3 cm. This region of diminished resistance protrudes when the patient coughs. Treatment of his neglected lues may improve this condition. A protective corset over this weakened area seems indicated.

An electrocardiogram, May 10, 1937, by Dr. R. V. Patterson, showed: "The rate is 80 per minute; the rhythm is regular; the conduction function is normal; left ventricular hypertrophy and myocardial degeneration are definitely indicated."

Orthodiagraphic studies made by Dr. John T. Farrell, Jr., May 11, 1937, showed little, if any, enlargement of the heart. He states: "The third and fourth ribs on the left side are deformed anteriorly and there is an adhesion deforming the left half of the diaphragm. Outside of these variations the intrathoracic structures are essentially normal. Looking at the film, the heart appears to be a little larger than the average but with the measurements of the orthodiagram it is well within normal limits."

AN AMBULATORY TREATMENT OF FRACTURE OF THE PATELLA

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IN THE ANNALS OF SURGERY, 101, 1082–1090, April, 1935, there appeared an article on "An Ambulatory Method of Treating Fractures of the Patella," by Roger Anderson of Seattle. His method requires: "Reduction by the application of skeletal traction to the upper patellar fragment, and immobilization through the agency of a plaster case in which are incorporated both this superior transfixion and a distal anchoring pin passed through the upper end of the

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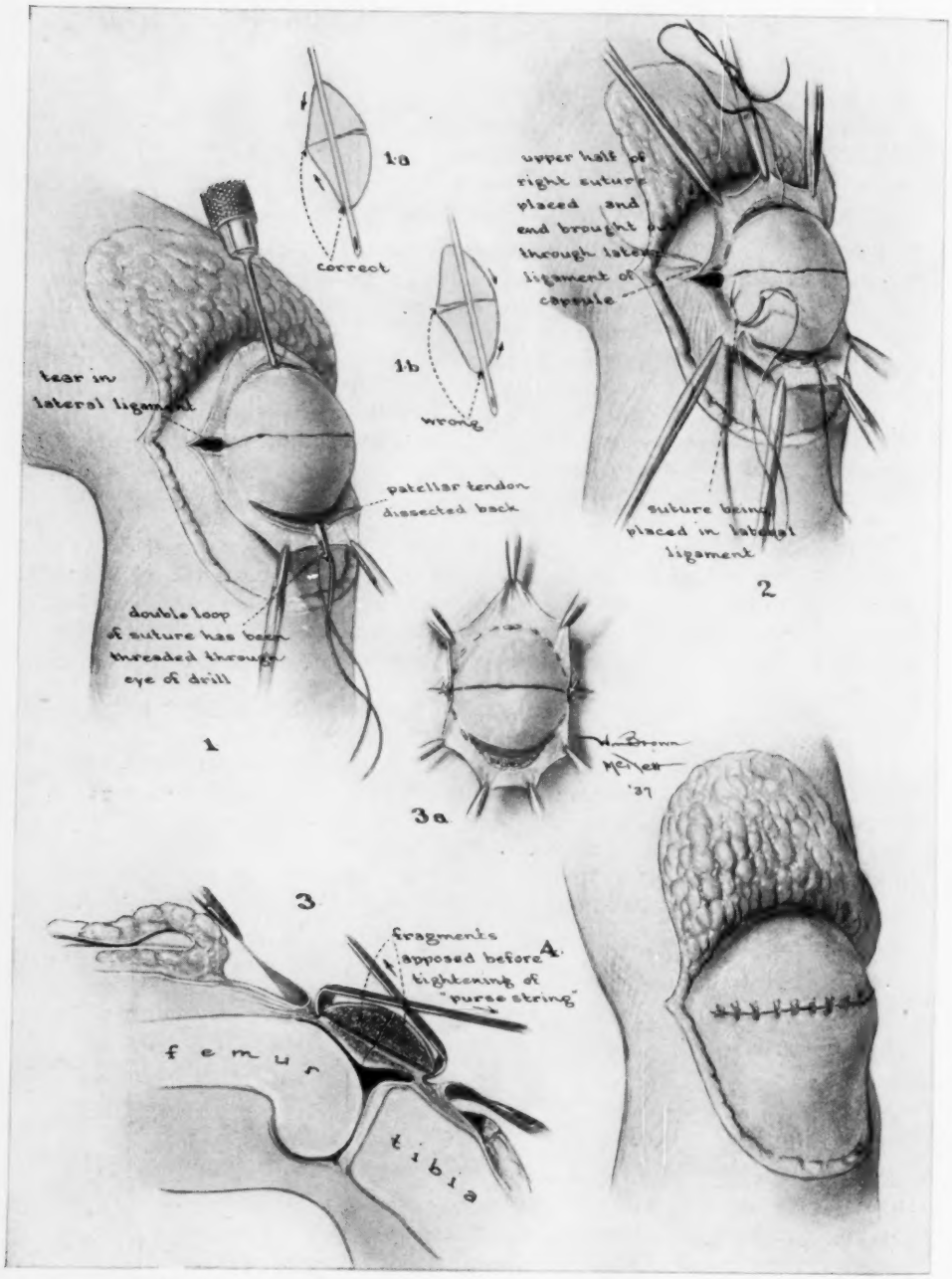


PLATE I.—Drawings showing the various procedures described in the text.

tibia." This technic, together with the rather cumbersome apparatus required to maintain reduction, seems unnecessarily complicated when compared with a simpler and equally efficient method in use in our clinic. The latter procedure is a modification of the operation employed by Professor Delbet of Paris.

A horseshoe-shaped incision is made over the patella, and the knee joint is exposed sufficiently to allow the removal of blood clots. The aponeurosis of the quadriceps muscle is elevated from the anterior surface of the patella in order to expose the line of fracture adequately. By means of a sharply pointed awl, vertical perforations are made through the central portions of both fragments. A double strand of silkworm gut is threaded through the eye of the awl to serve as a tractor for the "metallic silk" used for fixation of the fragments. This metallic suture consists of a finely twisted bronze-aluminum wire manufactured by Shearer of Bern. Its caliber is about one millimeter, which is too great to allow threading it through the eye of the perforating instrument, hence the use of the silkworm-gut tractor. In some cases the procedure is facilitated by perforating and drawing the suture through each fragment separately. A strand of wire 45 to 50 cm. in length will usually be adequate. After drawing the doubled strand through the two fragments from below upwards, so that equal lengths project from each orifice, the loop formed at the upper end is cut. Then, again using the silkworm-gut threaded on a heavy needle as a tractor, each of the four lengths of "metallic silk" is woven through the tendon expansion close to the lateral margins of the patellar fragments towards the line of fracture.

At this point the joint is filled with Calot's fluid,* an antiseptic olive oil compound, in order to prevent the formation of adhesions and to facilitate early mobilization. With the aid of a Farabeuf clamp, or other heavy clamp, an assistant then brings the fragments into anatomic alignment, while the operator draws tightly and knots the adjacent ends of wire on the medial and lateral aspects of the patella. The margins of the reflected quadriceps aponeurosis are approximated with No. 2 chromic catgut and the skin is closed with an intradermic suture of silkworm-gut.

Immediately postoperatively, a simple wooden splint is applied posteriorly for immobilization. This is worn until the fifth day when it is removed and active motion of the knee encouraged. On the tenth day the patient is allowed out of bed with the splint reapplied to afford confidence. On the twelfth day the splint is discarded and walking is allowed without restraining apparatus.

We have employed this method with consistently excellent results for more than 20 years. The rigid fixation of the fracture allows early resumption of knee motion, which in turn prevents intra-articular adhesions and the extensive atrophy which commonly follows prolonged immobilization of the knee. In addition the duration of hospitalization and the duration of disability are considerably shortened.

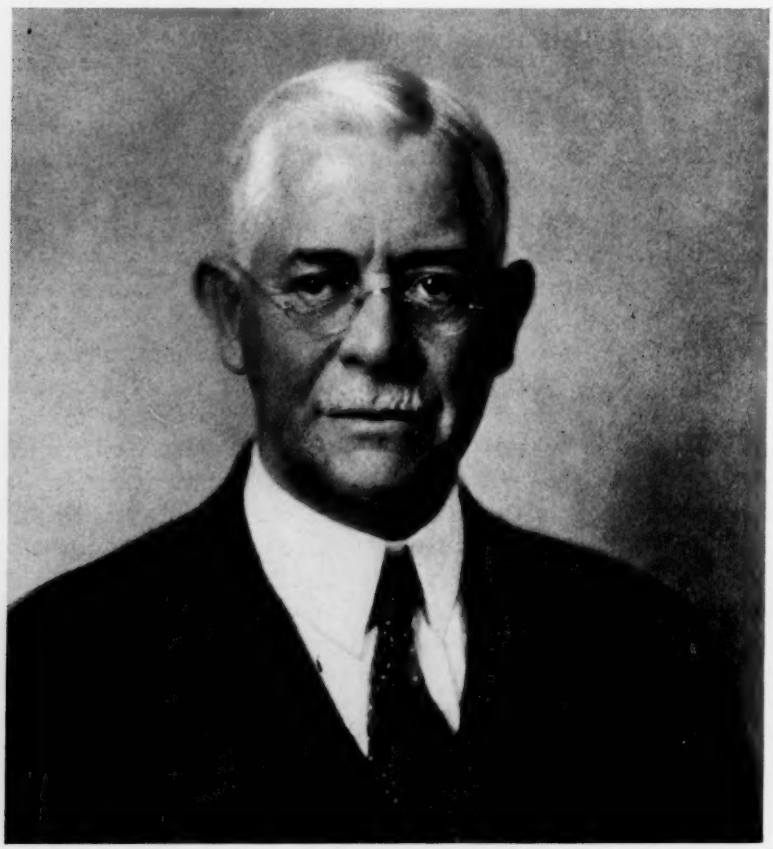
* Calot's fluid: Creosote, 3 grams; iodoform, 7 grams; ether, 25 cc.; olive oil (sterilized) 50 cc.

MEMOIR

INGERSOLL OLMSTED

1864–1936

DR. INGERSOLL OLMSTED, of Hamilton, Ontario, whose death occurred in his seventy-third year, on November 12, 1936, was one of Canada's most distinguished and respected surgeons. He was born in Ancaster, and his early education was at the Collegiate Institute of Hamilton. He received his M.B.



INGERSOLL OLMSTED, M.D.

degree from the University of Toronto, in 1887, and following that went to Philadelphia to be an intern in the Germantown Hospital. He returned to Hamilton in 1888, became resident physician in the Hamilton City Hospital and while there founded a training school for nurses. Doctor Olmsted maintained such interest and activity in the fundamental fields, particularly bac-

teriology, that he was offered an assistant professorship in that field at the University of Pennsylvania in 1893. Soon after he accepted this position he used himself as the subject of an experiment; an infection developed and it was necessary to amputate his right leg below the knee. On recovering from this, he resigned his position and went abroad where he studied in the clinics of Great Britain and continental Europe. When he returned to America, he continued his studies at Johns Hopkins University, and again returned to Hamilton where he set up in private practice, confining his work almost entirely to general surgery. Doctor Olmsted was a Fellow of the Royal College of Surgeons of Canada and of the American College of Surgeons, and he was honored in 1934 by the Hamilton Academy of Medicine with a life membership in recognition of his contributions to medical science. Surviving besides his wife, Edith Olmsted, are two sons, Archie and Dr. Alexander I. Olmsted, both of Hamilton, and a daughter, Mrs. George Hendrie.

The surgical career of Doctor Olmsted, extending as it did over a period of almost 50 years, exemplifies the changing status of the general surgeon, for it is not now possible that a general surgeon can encompass with the same degree of proficiency as many fields as Doctor Olmsted, with his inquisitive mind, could master. Surgeons of his day were confronted with the necessity of acquiring experience in many of the technical diagnostic fields, and since many of these were in their early stages of development, it was possible for such an energetic, studious and serious-minded worker as Doctor Olmsted, who had already had a sound training in the fundamental sciences, to learn what was known at that time in such fields. For example, he was a competent roentgenologist, did his cystoscopic examinations, was one of the the earliest to use the bronchoscope, carried on his routine clinical laboratory work, and made his pathologic examinations, and on this wide knowledge of diagnostic procedures built his surgical practice. It might be expected, therefore, that a surgeon with such a background would be an astute diagnostician of keen surgical judgment, and not only was this true of Doctor Olmsted, but he was also a master technician and always the true physician in the care of his patients.

In his every activity, whether in the practice of his profession or in his enjoyment of the out-of-doors, particularly in golf, hunting and fishing, his inspiring enthusiasm and zealous study made him always a stimulating teacher, companion and colleague. The influence of such a man and his work in a community detached from any teaching center of medicine cannot be overestimated, and he was the acknowledged leader of his profession in his part of Canada. His death is a loss to the medical profession, not only of Canada, but also to those who came under his tutelage, wherever they have gone.

DONALD C. BALFOUR.

BOOK REVIEWS

POSTGRADUATE SURGERY. By Rodney Maingot, F.R.C.S. (Eng.), Senior Surgeon to the Royal Waterloo Hospital and to the Southbend General Hospital; later Chief Assistant to a Surgical Unit, St. Bartholomew's Hospital. Three volumes, 5,584 pages. New York: D. Appleton-Century Company, Inc., 1936.

"Postgraduate Surgery," edited by Rodney Maingot, attempts to cover in a practical manner the whole field of surgery. In this creditable work the American reader is made acquainted with the leading surgical teachers of Great Britain, particularly of London. The references are few and, as a rule, are unfamiliar to the American student. Many of the technical details of operative surgery described herein are somewhat different from American surgical practice and are valuable as offering a ready means for comparison and evaluation. One's enthusiasm for the work under discussion will depend largely upon what we mean by "postgraduate surgery." The editor in his preface states that "the work has been written specially for postgraduates engaged in the practice of surgery; for senior resident officers; for fellowship candidates and for medical officers of the fighting services as well as for the busy general practitioners who may be called upon to undertake urgent surgical measures and who are desirous of keeping abreast with all the modern developments in surgery." The reviewer is willing to subscribe to the first four categories, but is emphatic in his belief that this is not a work for the busy general practitioner who may be called upon to undertake urgent surgical measures.

"Postgraduate Surgery" is presented in three volumes, containing 5,584 pages, and a thousand illustrations, each volume having an extensive index. The material in Volume I is presented in five parts: (1) Anesthesia; (2) abdomen; (3) rectum and anus; (4) roentgen ray diagnosis; (5) radium therapy. Volume II is in 11 parts devoted to the head; spinal column and salivary glands; neck; breast; thorax; female genital organs; urinary system and male genital organs; sympathetic nervous system; adrenal gland; injection therapy; infections of the hand, and a section on orthopedics. Volume III is a miscellaneous arrangement of 24 parts devoted to a conjurie of surgical topics, including a second section on orthopedics; cardiovascular system; plastic surgery; obstetric surgery; lymphatic system. Following thereafter are hernia; deep roentgen ray therapy; venereal disease; eye, ear, nose, pharynx and throat, with a part devoted to tonsils and adenoids; tongue; esophagus; jaws; teeth, *etc.*, and concluding with the thymus gland. It is apparent that in a consideration of modern surgery no one mind can hope to grasp even the fundamentals of such a wide and diverse grouping of surgical topics and probably the arrangement of these parts came as the result of the extension of the editor's thought for completeness. The range of material is encyclopedic and has

stimulated the reviewer to read sections wholly outside the beaten track of the restricted specialties of this country. This work is in fact a series of monographs and as such presents an uneven texture of presentation. Some of the contributions are outstanding and invaluable—abdomen, rectum and anus, roentgen ray diagnosis, urinary system and male genital organs, and lymphatic system. With few exceptions there is an undue prolixity and too much space is consumed in mere tabulation and disjointed paragraphs which render the reading difficult to follow. One senses the main impress of continental writers on English surgical thought as opposed to the contributions of American authors. It comes somewhat as a shock to see the words "vomits" and "feeds," *etc.*, used as substantives, together with the recommendation of remedies that are distinctly proprietary and apparently have not been passed upon by any group for new and nonofficial remedies. Many "drugs" that are in daily use in Great Britain are totally unknown in the United States.

The American opinion in regard to peptic ulcer is distinctly at variance with the presentation in Volume I, Chapter VI—"the treatment of chronic peptic ulcer is primarily and essentially medical." This statement without proper qualification is overly dogmatic and is not in consonance with American experience. Apparently, the various contributors have had considerable difficulty in limiting the scope of their presentation. Some have a minimum of description for the clinical phases of the condition under discussion but are most extensive in technical details of operative procedures. Others pass over the technical part and devote most of their space to descriptive surgery. One reads with considerable doubt "after the Polya types of operation, obstruction is very rare." Section 4, Chapter I "the medical treatment of gastric, duodenal and anastomotic ulcer" consists of four and one-half pages and contains some rather startling statements: "If suitable treatment is given for a sufficient period, nearly every gastric ulcer eventually heals, as well as about 75 per cent of duodenal ulcers, and 50 per cent of the much more intractable anastomotic ulcers which follow gastric operations"; "When the ulcer is healed . . . the patient should begin the post-ulcer regimen which he should keep up for the rest of his life"; "The suitable diet should not form clots in the stomach," yet in the next paragraph prepared chalk is given as "it has the advantage of being insoluble."

Hepatic failure is discussed under the general term "cholemia" and while "liver deaths" are mentioned, the author did not have a very clear understanding of just what is meant by this serious type of complication. Section 8, on the pancreas, consists of exactly five pages with nine illustrations; eight of them being devoted to methods by which pancreatitis may be produced at operation.

The reviewer searched in vain for the name of John B. Murphy either in the indices or in the text on peritonitis. This was particularly surprising because the modern conception of peritonitis has been developed in the last 35 years. According to Sampson Handley the names of Lawson Tait, Malcolm, Treves readily come to mind and the pathologic interpretation of

peritonitis by Dudgeon and Sargent is associated with the name of John B. Murphy, on the operative and therapeutic side.

Orthopedics is considered in Part XVI of Volume II and continued in Part XVII of Volume III, both sections under the same authorship. In Volume II, page 1,905, diverticula of the esophagus draw nine lines of description and the author provides a single illustration which shows that the "sac has been displaced and stitched in upright position." Additional information on esophageal diverticula is given in Volume III, pages 4,824 and 5,054. In spite of this the subject is very inadequately covered. Disease of the thyroid gland receives but two-thirds of a page of description and the section on radical operation on the breast is very brief and without any illustrations. The hormonal or endocrine treatment of chronic cystic mastitis is not mentioned. In Part IX, the section on the thorax is divided into two sections, section 1 dealing with medical conditions and section 2, surgery of the thorax.

Many of the operations illustrated in the section on gynecology are implemented by instruments unknown to American students. One's risibilities are touched on reading on page 2,586 on "Sterility in Women": "Being American she was thoroughly up-to-date and had a 'gold' button introduced into the cervix immediately before marriage." In consonance with present day teaching the endocrine background of the menstrual cycle should merit a fuller discussion.

The Injection Treatment of Hernia (Volume II, Part XIV, section 1), is in the nature of a special pleading. The author's advocacy is not confirmed by the American experience in the treatment of hernia by injection. Figure 1,839, page 3,254, depicting the technic of an injection into the left inguinal canal, has no place in any surgical textbook. The surgeon (?) in street clothes with the ubiquitous wrist watch on his left arm, is making an injection into the left inguinal region of an undraped patient. There is no visible evidence of adequate preparation of the patient or of the operator for a surgical procedure under aseptic conditions. Irrespective of the merits of the injection treatment of hernia the technical procedure should be surrounded always with the same safeguards as accompany other surgical procedures.

Many of the monographs in this system are excellent. In fact, most of them are first class presentations of the subject. For the students the work is primarily designed to serve it is to be recommended. For the American surgeon of experience and competency it is valuable. A knowledge of English and continental surgical thinking should prove useful in rounding out our own surgical knowledge.

The publisher has produced three very ornamental volumes. But, what a load to handle! Volume I weighs eight pounds, Volume II eight and one-half pounds, and Volume III nine pounds, and each one is handled with the greatest difficulty with or without the aid of a bookrest. It seems a pity that each volume was not subdivided, lighter paper employed and smaller compass given to main subdivisions in order that the books could be handled easily and without fatigue. In comparison with previous surgical publications from

British authors these three volumes are following the best tradition of English surgery. Lucidity of expression, conservatism and a background of good surgical judgment are in keeping with the best of surgical thought. The work is recommended to surgical interns, residents, and to the rising generation of surgeons. There is also an additional appeal to those already in the ranks of surgery to see in its entirety a splendid pageant of modern surgery.

CHARLES GORDON HEYD.

THE MANAGEMENT OF FRACTURES, DISLOCATIONS, AND SPRAINS. By John Albert Key, B.S., M.D., and H. Earle Conwell, M.D., F.A.C.S. Second Edit. Cloth. Pp. 1,246 with 1,222 illustrations. St. Louis, C. V. Mosby Company, 1937.

The authors have written an excellent book on the treatment of acute injuries of the bones and joints. They have covered the acute phase of the subject completely and have given in detail the technic, indications, counter-indications, and dangers of the various methods of treatment.

Very little space has been allotted to the chronic phase of bone and joint injuries; malunion and nonunion, the treatment of which constitutes a large part of the practice of orthopedic surgeons. Although it would have been desirable to make the book complete by adequately covering this phase of the subject, the authors have admirably fulfilled their purpose, as stated in the preface, of writing a book for the student, the general practitioner, and the surgeon.

ROBERT L. PRESTON.

BOOKS RECEIVED

THE receipt of books for review is hereby acknowledged. This statement shall be regarded as sufficient acknowledgment of the courtesy of the publishers. Selections will be made for review predicated upon the interests of the readers of the ANNALS OF SURGERY and as space permits.

THE 1936 YEAR BOOKS OF GENERAL SURGERY, Edited by Evarts A. Graham, M.D., UROLOGY, Edited by John H. Cunningham, M.D., PEDIATRICS, Edited by Isaac A. and Arthur F. Abt, M.D., GENERAL MEDICINE, Edited by Doctors Dick, Brown, Minot, Castle, Stroud and Eusterman, OBSTETRICS AND GYNECOLOGY, Edited by Joseph B. DeLee, M.D., and J. P. Greenhill, M.D., GENERAL THERAPEUTICS, Edited by Bernard Fautus, M.D., and Samuel J. Nichamin, M.D., EYE, EAR, NOSE AND THROAT, Edited by E. V. L. Brown, Louis Bothman, George E. Shambaugh, Elmer W. Hagens and George E. Shambaugh, Jr., M.D., NEUROLOGY, PSYCHIATRY AND ENDOCRINOLOGY, Edited by Hans H. Reese, M.D., Harry A. Paskind, M.D., Ph.D., and Elmer L. Sevringhaus, M.D., DERMATOLOGY AND SYPHILOLOGY, Edited by Fred Wise, M.D., and Marion B. Sulzberger, M.D., RADIOLOGY, Edited by Charles A. Waters, M.D., Whitmer B. Firor, M.D., and Ira S. Kaplan, B.Sc., M.D., Chicago: The Year Book Publishers, Inc., 1936.

SYNOPSIS OF GYNECOLOGY. By H. S., and R. J. Crossen, M.D. 2nd ed. St. Louis: C. V. Mosby Co., 1937.

SYNOPSIS OF DIGESTIVE DISEASES. By John J. Kantor, Ph.D., M.D. St. Louis: C. V. Mosby Co., 1937.

SYNOPSIS OF GENITO-URINARY DISEASES. By Austin I. Dodson, M.D. 2nd ed. St. Louis: C. V. Mosby Co., 1937.

TEXTBOOK OF SURGICAL NURSING. By Henry S. Brookes, Jr., M.D. St. Louis: C. V. Mosby Co., 1937.

TEXTBOOK OF GENERAL SURGERY. By Warren H. Cole, M.D., and Robert Elman, M.D. New York and London: D. Appleton-Century Co., Inc., 1936.

PROCTOLOGY. By Frank C. Yeomans, M.D. New York and London: D. Appleton-Century Co., 1936.

UROLOGY. By Edward L. Keyes, Ph.D., F.R.C.S. (Hon. London), and Russell S. Ferguson, M.D. 6th ed. New York and London: D. Appleton-Century Co., 1936.

SURGICAL PATHOLOGY OF THE DISEASES OF THE NECK. By Arthur E. Hertzler, M.D. Philadelphia: J. B. Lippincott Co., 1937.

THE 1937 YEAR BOOK OF THE EYE, EAR, NOSE AND THROAT. Edited by E. V. L. Brown, M.D., Louis Bothman, M.D., George E. Shambaugh, M.D., Elmer W. Hagens, M.D., and George E. Shambaugh, Jr., M. D. Chicago: The Year Book Publishers, 1937.

THE 1937 YEAR BOOK OF UROLOGY. Edited by John H. Cunningham, M.D. Chicago: The Year Book Publishers, 1937.

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Contributions in a foreign language when accepted will be translated and published in English.

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